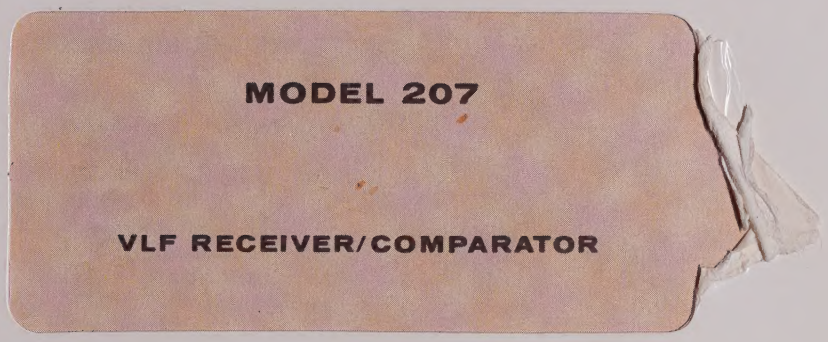
INSTRUCTION MANUAL



FLUKE
MONTRONICS, INC.
A SUBSIDIARY OF JOHN FLUKE MFG. CO., INC.

MODEL 207

VLF RECEIVER/COMPARATOR

INSTRUMENT SERIAL NO. _____

APRIL, 1967

MONTRONICS, INC.
Subsidiary of John Fluke Mfg. Co., Inc.
Seattle, Washington 98133

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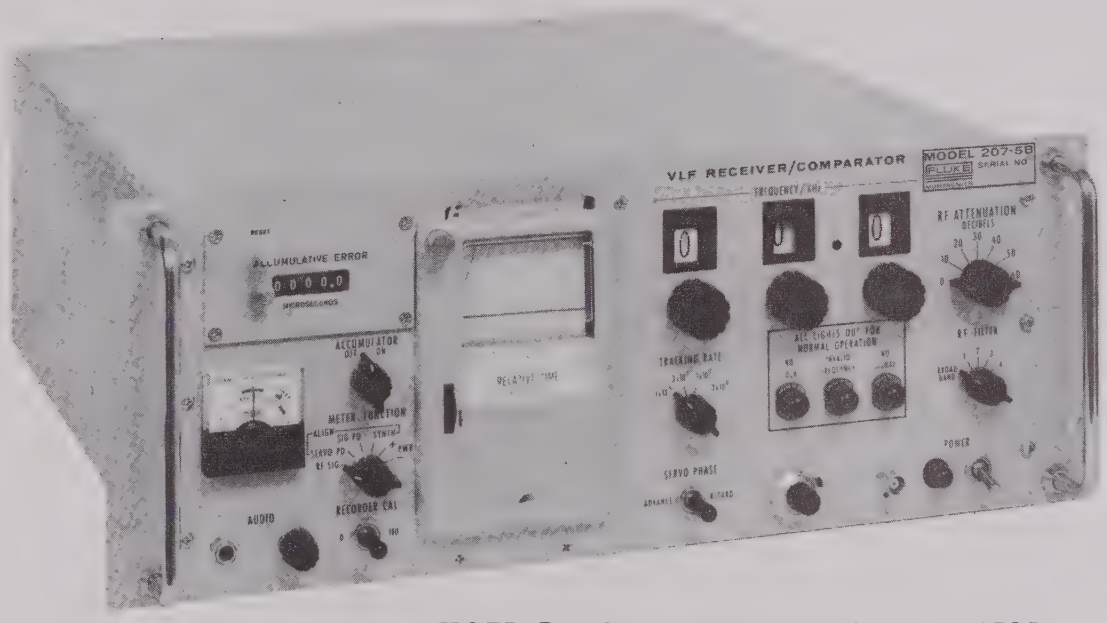
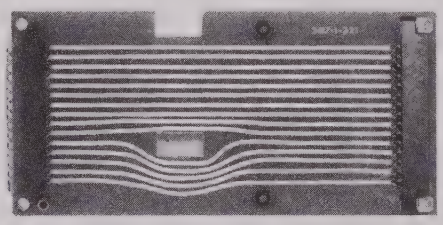
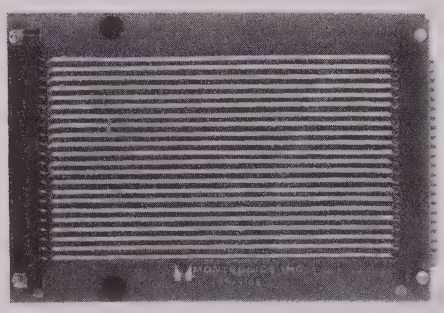
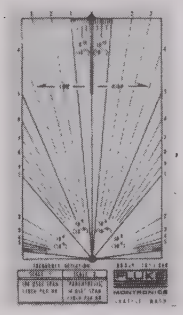
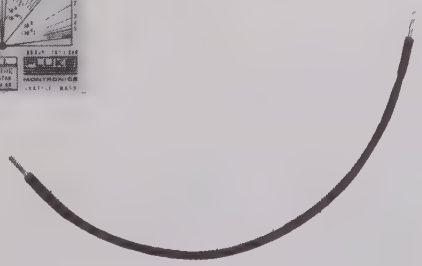


MODEL 207-5B VLF RECEIVER/COMPARATOR









STANDARD ACCESSORIES SUPPLIED WITH THE 207 SERIES INSTRUMENTS

SECTION I

INTRODUCTION AND SPECIFICATIONS

1-1. PURPOSE

1-2. This instruction manual is for use with the 207 series VLF Receiver/Comparators. These instruments compare local frequency standards to received very-low-frequency (vlf) and low-frequency (lf) standard frequency broadcasts. Frequency coverage is from 8.0 to 31.9 kHz in steps of 100 Hz with an additional channel at 60.0 kHz. Thus, local frequency standards may be calibrated by comparing them to frequencies based on both UT2 and A1 time scales.

1-3. STANDARD FREQUENCY BROADCASTS

1-4. A frequency standard is the only local standard that can be calibrated directly against the national standard anywhere in the world. High-frequency (hf) standard signals (stations WWV and WWVH) have been broadcast for many years in the United States by the National Bureau of Standards. However, the propagation path of hf signals include one or more reflections from ionospheric layers. Due to the vertical movement of this reflection layer, the transmission path length changes causing noise and doppler-shift effects. Shifts in the signal of one millisecond are not uncommon. Thus, high accuracy frequency measurements must be made by observing the signal over a time period that is extremely long compared to the transmission errors. Because of the long observation periods required, hf signals are no longer adequate for many applications.

1-5. The National Bureau of Standards, the U.S. Navel Laboratory, and England's National Physical Laboratory have been broadcasting vlf and lf signals for a number of years. Transmissions in the vlf and lf range have propagation paths following wave-guide propagation modes. In effect, the signals are guided between the earths surface and the ionosphere. Propagation path changes are therefore small and the propagation for vlf and lf is several orders of magnitude more stable than for hf. A comparison accuracy of a few parts in 10^{11} may be achieved in a 24 hour period. It would take several months to even approach the same accuracy with hf signals.

1-6. MODEL DIFFERENCES

1-7. The basic VLF Receiver/Comparator is the Model 207-1. The Model 207-3, 207-4, 207-4B, 207-5, and 207-5B are standard options. The differences of these models from the basic 207-1 are listed in Figure 1-1.

1-8. FUNCTIONAL DESCRIPTION

1-9. The 207 VLF Receiver/Comparator is a completely electronic phase tracking receiver. A 1.1 kHz signal derived from the local frequency standared is phase corrected to a 1.1 kHz signal derived from the received vlf or lf transmission signal by means of an electronic phase shifter. If the local frequency standard is at exactly the right frequency, there will be a constant phase shift. However, if the local frequency standard is high or low in frequency, the phase shift produced by the electronic phase shifter will change with time. This changing phase shift is used to produce a time-interval error which is recorded on a strip chart recorder. In addition, a cumulative total of the error to the nearest tenth of a microsecond is maintained on a counter called the digital error accumulator. The fractional error of the local frequency standard is calculated by dividing the time-interval error by the observation period.

1-10. ACCESSORIES

1-11. The following accessories are available for use with the 207:

a. VLF WHIP ANTENNA: The Model 207-1-450 VLF Whip Antenna is specially designed for use with the 207. A field effect transistor circuit in the base of the antenna provides impedance matching from the antenna to a 50 ohm transmission line. In addition, this circuit provides rf amplification making the antenna about 15 db more sensitive than comparable antenna systems. Operating power for the field effect transistor is supplied through the center counductor of the coaxial cable from the receiver. The whip length is 102 inches. The antenna is supplied with 100 feet of RG-58A/U coaxial cable.

MODEL	DESCRIPTION
207-3	Provides a means whereby a secondary local frequency standard can be compared to a primary local frequency standard. To make this measurement, the signal to be compared to the primary standard is applied to a front panel BNC connector. This signal automatically disables the rf section of the receiver and indicates this mode of operation by the illumination of the NO SIGNAL light. The relative phase comparison between the secondary standard and the primary standard may then be read directly from the strip chart recorder in the same manner as when the primary standard is compared to the received vlf signal. Removal of the secondary standard returns the receiver to normal operation. The strip chart recorder will resume the previous comparison between the primary standard and the received vlf signal without loss of phase information as long as they have not changed phase by more than $\pm 180^{o}$ during the period of measurement.
207-4	Incorporates a 1 MHz frequency standard within the receiver which is intended for use as a local primary standard where one is not already available or an additional primary standard when desired. The receiver thus provides a frequency source for the laboratory that is referenced to the vlf standard frequency broadcasts. The internal standard is a 1 MHz quartz crystal oscillator that offers moderately high stability to calibrate laboratory instruments such as frequency counters. The crystal is housed in a proportionally controlled oven with all solid-state electronic circuitry. The output frequency may be adjusted by a front panel control with the output being available at a rear panel BNC connector.
207-4B	Same as the 207-4 with the addition of an internal rechargeable battery pack designed to power the internal standard in the event of losing ac line power. Upon power failure the receiver will automatically switch over to the internal batteries. These batteries will operate the standard for a minimum of 4 hours maintaining the oscillator frequency within 2 parts in 10^{9} of its initial drift rate. The batteries are recharged in 16 hours of normal receiver operation by an internal charging circuit.
207-5	Combines the features of the 207-3 and 207-4.
207-5B	Combines the features of the 207-3 and 207-4B.

Figure 1-1. STANDARD OPTIONS TO THE BASIC MODEL 207-1

b. CHASSIS SLIDES: The 207 chassis is equipped with mounting hardware for standard Jonathan 110QD-18-A-2 chassis slides.

c. PLUG-IN NARROW-BAND RF FILTERS: Individual filters are available for each frequency within the operating range of the 207. Order by part number 207-1-422XXX where the center frequency in multiples of 100 Hz is denoted by the last three figures.

1-12. RECEIVING INSPECTION

1-13. GENERAL

1-14. Immediately upon receipt, throughly inspect the instrument for any damage that may have occurred in transit using the mechanical and electrical checks given here. If any damage is noted, follow the instructions outlined on the warranty page at the back of this manual.

1-15. MECHANICAL CHECK

a. Unpack the instrument and verify that all accessories shown in the frontispiece have been received.

b. Inspect the instrument for any physical damage such as scratched or dented panels, broken knobs or connectors, etc.

c. Remove top cover, inner top cover, and bottom cover; press all printed circuit boards in place; and inspect for loose or damaged components.

1-16. ELECTRICAL CHECK

1-17. The instrument may be checked for electrical operation by performing the First Time Operation procedure of Section II.

1-18. SPECIFICATIONS

CALIBRATION ACCURACY
Short term and long term stability is better than ±0.5 microsecond. Under normal laboratory conditions intrinsic calibration accuracy (relative to received VLF carrier) is better than $\pm 1 \times 10^{-11}$ on a 24-hour basis.

FREQUENCY COVERAGE
8.0 to 31.9 kHz in steps of 100 Hz, plus channel at 60.0 kHz.

RECEIVER SENSITIVITY
10 nanovolt signal at 50 ohm antenna input terminal enables phase tracking; tracking is maintained at an input signal-to-noise ratio of -50 db (Gaussian noise measured in a 1 kHz bandwidth). Sensitivity stated is that of receiver exclusive of antenna.

SELECTIVITY AND SPURIOUS REJECTION
All spurious voltages, including image frequencies and signal frequencies from 0 to 10 MHz beginning at 100 Hz either side of the selected channel, are rejected by 60 db.

DYNAMIC RANGE
Symmetrical clipping in rf and if stages assures reliable phase-locked servo operation over an 80 db range of carrier level without the use of agc. Less than ±0.25 microsecond phase shift will be experienced for a 40 db change in signal level. The total signal level operating range is in excess of 140 db, including 60 db front panel attenuator.

RF FILTER CAPABILITY
A front panel five-position switch permits selection of either a broadband filter or narrowband filters. Broadband filter position will normally be used for tracking all channels; optional plug-in narrowband filters provide additional frequency selectivity for specific channels. Filters may be ordered for any frequency within range of the receiver.

BANDWIDTH
a. RF bandwidth (narrowband filters) nominal 1.5% of center frequency.
b. IF bandwidth - nominal 50 Hz.
c. Servo bandwidth (equivalent noise bandwidth) - equal to selected tracking rate times received frequency. Thus servo bandwidth when receiving 16 kHz is from 0.00048 Hz to 0.016 Hz depending on tracking rate.

PHASE TRACKING SERVO
An all-electronic servo maintains a phase shifted reference signal in phase null condition relative to vlf carrier. The maximum phase tracking rate is 1×10^{-6} for 5-second time constant, 3×7^{-7} for 15-second time constant, 1×10^{-7} for 50-second time constant, and 3×10^{-8} for 150-second time constant. The nominal servo deadband is less than ±0.1 microsecond. Maximum phase tracking error is 5 microseconds at maximum fractional frequency offset. Tracking rate is selected by a front panel rotary switch to allow four different rates as above. Manual servo slewing is provided by a momentary contact, center-off toggle switch provided to advance or retard servo phase at a nominal 1 microsecond/second rate.

AUTOMATIC SERVO DISABLE CIRCUIT
An electronic switch is provided to disable the phase servo whenever the vlf carrier drops below a minimum level; a front panel warning lamp lights at the same time. Tracking resumes automatically when carrier returns.

STANDARD FREQUENCY INPUT
100 kHz, 1 MHz or any integral multiple of 100 kHz between these two frequencies.

INPUT LEVEL
0.2 to 5.0 volts rms into 1,000 ohms. Accepts sine wave, square wave or pulse input. Pulse amplitudes from 0.5 to 14.0 volts peak-to-peak.

FREQUENCY SYNTHESIZER
A frequency synthesizer generates a coherent local oscillator signal in 100 Hz increments between 59.1 kHz and 83.0 kHz, and at 111.1 kHz. Three rotary switches select the proper local oscillator frequency. An in-line decimal readout indicates the frequency of the received station. The phase of the coherent local oscillator signal is fixed by the synthesizer setting; the synthesizer, after being switched to other frequencies, shows less than ±0.05 microsecond shift when returned to its original setting.

DIGITAL ERROR ACCUMULATOR
A front panel digital counter is pulsed by the electronic phase servo and displays relative time difference between the local standard and vlf carrier. The counter accumulates up to 9999.9 microseconds. The counter dial may be manually set to zero or other desired initial reading independently of phase position of tracking servo.

FRONT PANEL RECORDER
A built-in recorder on the front panel presents a time history of the accumulated phase difference between the local standard and the received vlf carrier. Recorder utilizes an inkless stylus and operates at one inch per hour. Full scale chart width may be 10 or 100 microseconds of relative phase, selectable with a rear panel switch.

AUDIO OUTPUT
A built-in speaker and volume control for aural monitoring of the received vlf station at the 1.1 kHz intermediate frequency is provided. Head phone jack is also provided to override speaker.

AUXILIARY OUTPUTS
Following outputs are available on rear chassis BNC connectors:

a. Amplified vlf station signal at 1.1 kHz intermediate frequency and phase coherent with rf carrier.
b. 100 kHz square wave in phase with received vlf signal, 0.75 volt peak-to-peak.
c. 1 kHz square wave in phase with received vlf signal, 0.75 volt peak-to-peak.
d. 100 Hz square wave in phase with received vlf signal, 0.75 volt peak-to-peak.
e. Reference frequency offset 51.1 kHz from vlf carrier, 0.75 volt square wave.

Following outputs are available on rear chassis terminal block:

a. Relative time signal for external recorder; 0-1 ma represents 0-10 or 100 microseconds depending on span selected by rear panel switch. Rear panel switch controls span of relative time recording.
b. Event marker in parallel with NO SIGNAL indicator light on front panel, 0 or +13 vdc.
c. Event marker in parallel with NO LOCK indicator light on front panel, 0 or +13 vdc.
d. Output of signal level phase detector in parallel with rf Signal indication on front panel meter, 20 db range.

METER DISPLAY
Front panel meter, in combination with Meter Function Switch, indicates:

a. Relative carrier level; 20 db full scale plus indication of normal clipping operation of rf and if stages.
b. Servo phase detector balance and error voltage (zero-center).
c. Signal phase detector balance.
d. Synthesizer alignment.
e. Level indication from internal power supply at plus and minus 13 vdc

REAR PANEL CONTROLS
a. Antenna selector switch: 3-position rotary switch selects input from Model 207-1-450 VLF Whip Antenna, other 50 ohm antenna, or High Impedance long wire antenna.
b. Jumper on rear terminal block converts front panel indicator lights to "tell-tale" operation.
c. Coarse and fine adjustments of span for external recorder.
d. Span selector switch for relative time recorder.

PHYSICAL SIZE AND CONSTRUCTION
The receiver is designed for 19" relay-rack mounting, 7" high, 18" maximum depth behind panel. Net weight is approximately 35 lbs. The instrument is of modular construction, using printed circuit boards and integrated circuit modules.

POWER REQUIREMENTS
The receiver operates from 95-125 or 190-250 vac, 48-400 Hz, or from a dc source of ±12 vdc standby batteries. External standby battery, when used, automatically assumes full operating load in the event of primary ac power failure. All receiver functions including servo tracking are sustained without interruption with the exception of the graphic recorder. (DC chart drive and 230 vac chart drive available on special order.)

MODEL 207-3 VLF RECEIVER WITH ADDITIONAL COMPARISON INPUT

Input Signal Frequency: 1 MHz, 100 kHz or any integral multiple 100 kHz between these two frequencies.

Voltage: 0.5 to 14.0 volts peak-to-peak, sine wave, square wave or pulse.

Impedance: Greater than 1000 ohms.

Connector: Front panel BNC.

Controls: Completely automatic changeover from vlf receiver mode to comparison mode.

MODEL 207-4 VLF RECEIVER WITH INTERNAL STANDARD

Output Frequency: 1 MHz

Output Level: 1 volt into 50 ohms.

Stability: 24 hours (at shipment) $\pm 5 \times 10^{-9}$
24 hours (after 1 month) $\pm 2 \times 10^{-9}$
1 second interval, $\pm 2 \times 10^{-11}$

Warmup Time: Approximately 100 minutes to be within 1×10^{-7}.

Adjustment Range: By means of front-panel ten-turn potentiometer; approximately 4×10^{-10} per division with range of approximately 2×10^{-7}. Total mechanical adjustment approximately 6×10^{-7}.

MODEL 207-4B VLF RECEIVER WITH INTERNAL STANDARD AND RECHARGEABLE BATTERY PACK

Same as 207-4 with the addition of rechargeable batteries designed to power internal standard in the event of loss of ac line power.

Battery Discharge Time: Batteries will operate frequency standard for a minimum of 4 hours maintaining frequency within 2 parts in 10^9 of its initial drift rate.

Battery Change Time: Batteries are recharged in 16 hours of normal receiver operation.

MODEL 207-5 VLF RECEIVER WITH INTERNAL STANDARD AND ADDITIONAL COMPARISON INPUT

Combines features of the 207-3 and 207-4.

MODEL 207-5B VLF RECEIVER WITH ADDITIONAL COMPARISON INPUT, INTERNAL STANDARD, AND RECHARGEABLE BATTERY PACK

Combines features of 207-3 and 207-4B.

SECTION II

OPERATING INSTRUCTIONS

2-1. PREPARATION FOR USE

2-2. The Model 207 VLF Receiver/Comparitor may be prepared for use by properly installing the antenna and installing the receiver.

2-3. INSTALLING THE ANTENNA

2-4. Installing the antenna consists of selecting the type of antenna, selecting the location of the antenna, and mounting the antenna.

2-5. SELECTING THE TYPE OF ANTENNA. The Model 207 will work with many types of antennas. These antennas may be classified into three configurations. One of these configurations is the Model 207-1-450 Whip Antenna, which is specifically designed for use with the Model 207. A field effect transistor circuit in the base of the antenna provides impedance matching and power gain from the antenna to a 50 ohm transmission line. The 207-1-450 antenna provides very good reception while taking up only a small amount of space. The second configuration contains all normal 50 ohm antennas such as tuned and non-tuned antennas, matched ferrite antennas, etc. Directional antennas such as the loop antennas provide the advantage of more gain in one plane while attenuating noise from other directions. The last configuration consists of long wire antennas. Any one of the three antenna configurations may be fed into the single BNC ANTENNA input connector on the rear of the Model 207. The ANTENNA selector switch, also located on the rear panel, is used to select the 207-1-450 WHIP, 50 OHM, or HI Z position for the desired antenna configuration.

2-6. SELECTING THE ANTENNA LOCATION. The location selected for the antenna must be an area with adequate signal strength and low electrical interference.

2-7. The 207 receiver is designed to operate with the antenna located on the roof of the building. Steel-reinforced buildings may attenuate the received signal enough to prevent receiving one or more stations, depending on the location of the antenna, surrounding buildings and the transmitting stations. These stations can usually be received by locating the antenna just outside at least one side of the building. If required, the antenna may be located inside the building with a resultant loss in signal strength and increase in noise level.

2-8. Due to the extreme sensitivity of the 207, the antenna must be placed in an area of low electrical interference. Any equipment generating frequencies at or below the received frequency are possible sources of interference. Keep the antenna away from frequency counters, frequency dividers, arc welders and other high current machines, transformer vaults, and power distribution sub-stations (24 kHz is the 400th harmonic of 60 Hz line power).

2-9. MOUNTING THE ANTENNA. When mounting the antenna, consideration should be given to the orientation of the antenna, the transmission line connecting the antenna to the Model 207, and lightning protection for the equipment. Whip antennas should be mounted vertically; loop antennas should be operated with the desired station and antenna loop in the same vertical plane; and ferrite-core antennas should be operated broadside to the station.

2-10. A 50 ohm coaxial cable transmission line terminated with a male BNC connector at the receiver end should be used with all 50 ohm antennas. Normally, the Model 207-1-450 Whip Antenna is supplied with 100 feet of RG58A/U coaxial cable. Significantly more cable may be added, the maximum length of which is determined by the signal strength at the antenna. Considerable care should be taken when connecting a high impedance long wire antenna to the receiver. If coaxial cable is used as a lead in for a long wire antenna, the sensitivity of the antenna will be reduced significantly by the shunt capacitance of the cable to ground. An open wire transmission line run some distance inside a building may pick up an objectional amount of noise. Make sure the antenna used is grounded only at the receiver to prevent the possibility of ground loops.

2-11. When lightning protection is desired, the protective device should be connected in the low impedance portion of the antenna circuit on the outside of the building. For example, with the Model 207-1-450 Whip Antenna, the protective device should be connected between the antenna base and the lead in cable. If a lightning arrestor is connected in the high impedance portion of the antenna, the capacitance to ground will reduce the antenna sensitivity.

2-12. INSTALLING THE RECEIVER

2-13. Installing the receiver consists of rack mounting the instrument if desired; connecting input power, antenna, and frequency standard; and connecting to any output signals that are desired.

2-14. RACK MOUNTING. The Model 207 is normally shipped ready for use as a bench top instrument. If rack mounting is desired, simply mount the receiver by the front panel. For severe service, attach Jonathan 11QD-18-A-2 Chassis Slides to the hardware provided on the receiver.

2-15. INPUT POWER CONNECTIONS. Line power requirements for the Model 207 are 95-125 or 190-250 volts ac, single phase, 48 to 400 Hz, 45 watts. The instrument is normally supplied with dual primary windings connected in parallel for nominal 115 volt line operation with a 60 Hz recorder. Upon request, the instrument is supplied for nominal 230 volt line operation and other recorder frequencies. Connect input power to the instrument as follows:

a. Connect power plug to a 115 volt ac power outlet. If the instrument is wired for 230 volt operation, connect to 230 volts ac.

WARNING!

The round pin on polarized three-prong plug connects instrument case to power system ground. Use a three-to-two pin adapter when connecting to a two-contact receptacle and connect adapter grounding lead to a good earth ground. If the instrument is not grounded, spurious signals on the power lines may affect operation of the instrument.

b. If it is desired to change from one input voltage to another, rewire bottom of power transformer as instructed by decal on top of transformer. Then replace fuses as instructed on rear of instrument.

c. If it is desired to change from one input frequency to another, order and install a recorder motor of the proper frequency.

d. If it is desired to provide standby power to maintain operation during periods of line power failure, connect +12 volt and -12 volt batteries between ground and corresponding EXT BATTERY terminals on rear-panel terminal strip. The batteries should be of adequate capacity to supply 2.0 amperes to the +12 volt terminal and 0.4 amperes to the -12 volt terminal for the desired period of time. If it is desired to maintain recorder operation, use a dc chart-drive recorder motor.

2-16. COOLING REQUIREMENTS. The Model 207 will operate with ambient temperatures from 0° C to 40° C (32° F to 104° F). For either bench top or rack use, other instruments may be placed around the 207 as long as these instruments do not generate enough heat to raise the ambient temperature above 40° C. However, it should be remembered that increased temperature reduces the life of components in any instrument.

2-17. INPUT SIGNAL CONNECTIONS. Connect the input signals to the instrument as follows:

a. Connect antenna lead to rear panel ANTENNA connector and set ANTENNA selector switch to proper position for the antenna used.

b. Connect local frequency standard to rear panel 100 KHz - 1 MHz STD FREQ IN connector. Input from the standard may be a sine, square, or pulse waveform in any 100 kHz increment from 100 kHz to 1 MHz with a peak-to-peak value from 0.3 to 15 volts. The frequency of the standard must be within 1 part in 10^6 of its nominal value for the instrument to make a comparison with the received signal. The internal 1 MHz frequency standard of the Model 207-4, 207-4B, 207-5, or 207-5B may be compared to a received vlf signal by connecting the INTERNAL 1 MHz STD connector on rear of instrument to the 100 KHz - 1 MHz STD FREQ IN connector.

c. To compare two local frequency standards with the Model 207-3, 207-5 or 207-5B, connect the second local frequency standard to COMPARISON INPUT connector on front panel as instructed in paragraph 2-48.

2-18. OUTPUT SIGNAL CONNECTIONS. A number of auxiliary outputs are available from the rear-panel BNC connectors and terminal strip. All BNC outputs (100 KHz, 1 KHz and 100 Hz COHERENT OUTPUTS; 1.1 KHz IF output; CONV SYNTH output; and INTERNAL 1 MHz STD output) may be connected to the desired loads with coaxial cable such as RG53A/U.

a. The 100 KHz, 1 KHz and 100 Hz COHERENT OUTPUTS are all square wave with an open circuit voltage of at least 0.75 volts. These outputs are coherent with the received vlf signal. That is, there is a fixed ratio between the frequency of any one received signal and the frequency of any one of the coherent outputs.

b. The 1.1 KHz IF output is used to monitor the if signal.

c. The CONV SYNTH output provides a reference frequency that is offset 51.1 kHz from the received signal. This is a square wave with an open circuit voltage of at least 0.75 volts.

d. The INTERNAL 1 MHz STD output allows the use of the internal standard in the Models 207-4, 207-4B, 207-5 and 207-5B. This output may be paralleled to an external load and the receiver 100 KHz - 1 MHz STD FREQ IN connector.

e. The NO SIGNAL EVENT MARKER provides +13 volts dc with respect to the GROUND terminal when adequate signal is present and 0 volts when adequate signal is not present.

f. The NO LOCK EVENT MARKER provides +13 volts dc with respect to the GROUND terminal when the receiver is phase locked to the received signal and 0 volts when it is not locked.

g. The RF SIG terminal may be used to make potentiometric recordings of signal strength. Dynamic range is nominally +20 db relative to receiver sensitivity threshold.

h. The EXT REC terminal provides +1 ma full scale with respect to the GROUND terminal for loads up to 1000 ohms. Potentiometric recorders may be used by sampling the voltage across a load resistor placed between the EXT REC terminal and the GROUND terminal. To use an external recorder, connect recorder between EXT REC and GROUND terminals and calibrate as follows:

(1) Set SPAN switch to 100 USEC or 10 USEC as desired.

(2) Set POWER switch to the on position.

(3) Press RECORDER CAL switch to 0 and adjust recorder for an indication of 0. Release RECORDER CAL switch.

(4) Adjust EXT REC CALIB FINE adjust control at rear of instrument to center of its range.

(5) Press RECORDER CAL switch to 100 and adjust EXT REC CALIB COARSE adjust control for approximately 100 on recorder; fine adjust with EXT REC CALIB FINE adjust control. Release RECORDER CAL switch.

(6) Proceed with use of Model 207 as instructed under desired procedure.

2-19. FIRST TIME OPERATION

2-20. Operating the Model 207 for the first time involves initial instrument checkout and becoming familiar with normal operation indications, vlf station selection, tracking rate selection, and period measurement selection. However, before operating the instrument for the first time, the operator should become familiar with the location and function of the controls, terminals and indicators on the front and rear panel of the instrument. This information is given in Figures 2-1 and 2-2.

2-21. INITIAL CHECKOUT

2-22. The initial checkout of the Model 207 allows the operator to become familiar with the instrument and check for proper operation.

a. Make sure the instrument has been prepared for use as instructed in paragraph 2-1.

b. Disconnect antenna from ANTENNA input connector at rear of instrument.

c. Set RF ATTENUATION switch to 0 DECIBELS, TRACKING RATE to 1×10^{-6}, and POWER switch to the on position. The POWER indicator light will illuminate.

d. Within a few seconds the NO LOCK and NO SIGNAL lights will illuminate. Check this for each FREQUENCY/KHz channel of interest. These lights may flicker off for short periods of time due to noise. If the lights fail to illuminate, check for faulty bulbs by "press-to-test".

e. Set ACCUMULATOR switch to ON. The ACCUMULATIVE ERROR counter should cycle in a random manner due to noise.

f. Connect antenna to ANTENNA input connector at rear of instrument.

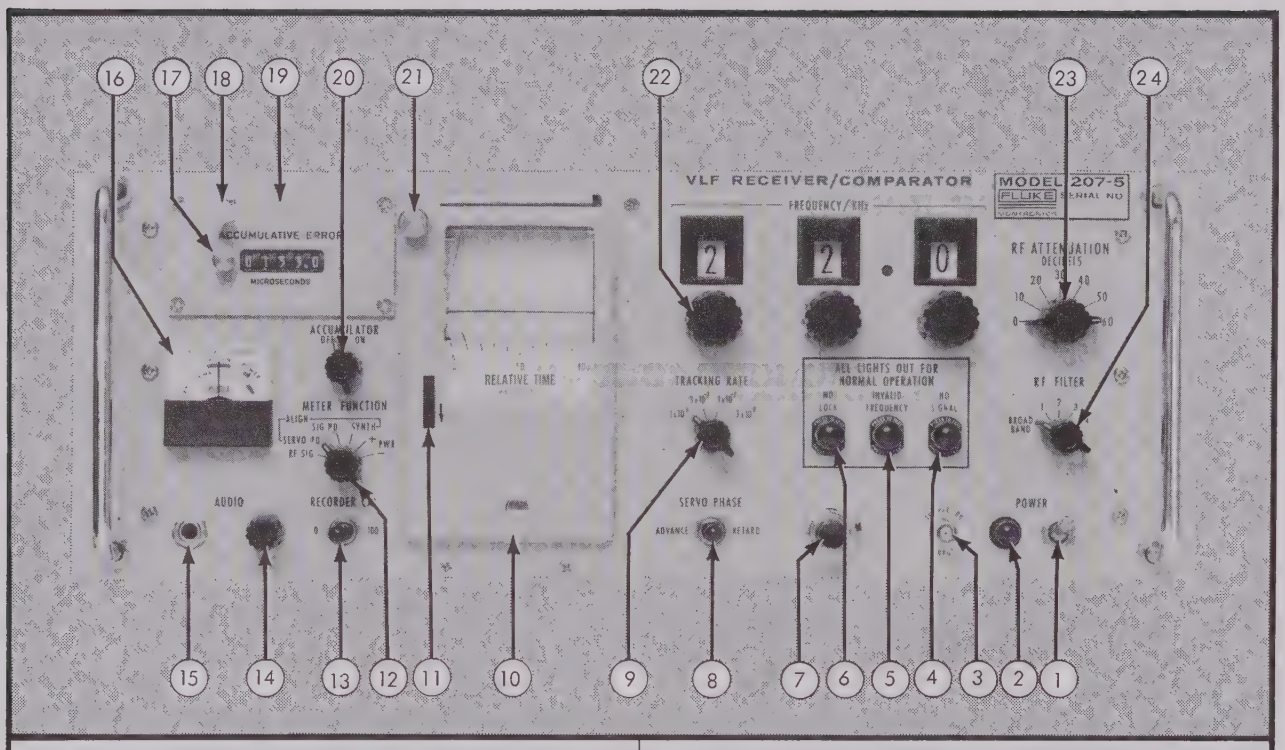
g. Adjust FREQUENCY/KHz dials to a desired station that is known to be broadcasting. The NO SIGNAL light should go out in a few seconds. The NO LOCK light may go out with the NO SIGNAL light or may remain on for up to 30 seconds. After the NO LOCK light goes out, the ACCUMULATIVE ERROR counter may continue in one direction without reversing for up to 15 seconds. When the instrument is locked onto the received signal with a minimum of error, the ACCUMULATIVE ERROR counter may oscillate back and forth by a few microseconds. When the NO LOCK light is on and the NO SIGNAL light is off, the ACCUMULATIVE ERROR counter rate will equal the TRACKING RATE. This means that when there is adequate signal but the instrument is not locked, it will drive toward lock at a rate equal to the TRACKING RATE.

h. Set TRACKING RATE to slowest position (narrowest bandwidth) consistant with the accuracy of the frequency standard used (see paragraph 2-36).

2-23. NORMAL OPERATION INDICATIONS

2-24. Indications of normal operation may be obtained from the signal lamps, the meter, and the speaker.

2-25. SIGNAL LAMP INDICATIONS. When the Model 207 is operating properly and is locked onto a station, all three front-panel signal lamps are extinguished. The INVALID FREQUENCY lamp illuminates when a frequency other than 8.0 to 31.9 and 60.0 kHz is set on the FREQUENCY/KHz dials; the NO SIGNAL lamp illuminates when the received vlf signal is inadequate to assure servo lock; and the NO LOCK lamp illuminates when the corrected signals from the local frequency standard are not in the proper quadrants for servo lock. These lamps are usually operated in the automatic mode where the lamps extinguish immediately after a fault is corrected. However, by removing the jumper on the rear-panel terminal strip, all three signal lamps are placed in the "telltail" mode. In this mode, the lamps remain on after a fault until the lamp is pressed to extinguish it. If the local frequency standard is off by more than 1 part in 10^6, the NO SIGNAL lamp will flash intermittently and the NO LOCK lamp will flash at a fairly high rate. This periodic flashing of the NO LOCK



(1) POWER Switch. Applies ac line power to instrument when set in the upper position.

(2) POWER On Indicator. Illuminates when ac line power is applied to instrument.

(3) COMPARISON INPUT Connector. Connects to a working frequency standard for the purpose of comparing it to the local primary standard connected at the rear of the instrument. Used only on the 207-3, 207-5, and 207-5B.

(4) NO SIGNAL Indicator. Illuminates when the received lf or vlf signal is not adequate to assure servo lock.

(5) INVALID FREQUENCY Indicator. Illuminates when a frequency outside the range of 8.0 to 31.9 and 60.0 kHz is set on the FREQUENCY/ kHz dials.

(6) NO LOCK Indicator. Illuminates when the corrected signals derived from the local primary frequency standard are not in the proper quadrants for servo lock.

(7) Internal Standard Adjustment. Varies the frequency of the 1 MHz internal standard. Each division represents about 4 parts in 10^{10} with a full range of approximately 2 parts in 10^{7}. Coarse adjustment (accessable by removing top cover of instrument) provides a total adjustment of approximately 6 parts in 10^{7}. Used only on the 207-4, 207-4B, 207-5, and 207-5B.

(8) SERVO PHASE Switch. Forces the phase shifter to ADVANCE or RETARD the phase of the signal referenced to the local primary standard at a nominal 1×10^{-6} (one microsecond per second) rate. May be used to advance or retard phase of RELATIVE TIME recording by a complete cycle at the received frequency if held long enough. Also may be used to check receiver lock by insertion of a phase error which the receiver will correct.

(9) TRACKING RATE Switch. Allows four tracking rates (expressed in maximum allowable fractional deviation from the nominal value of the local primary standard) of 1×10^{-6}, 3×10^{-7}, 1×10^{-7}, and 3×10^{-8} to be chosen. Normal operation is at 1×10^{-7}. The 1×10^{-6} and 3×10^{-7} tracking rates are useful for calibrating less stable frequency standards or frequency standards that have not been calibrated for a long time. The 3×10^{-8} tracking rate is normally used only with very stable frequency standards during poor signal-to-noise conditions.

(10) RELATIVE TIME Recorder. Makes a phase difference recording between the received signal and the output of the local primary standard being monitored or calibrated. Chart speed is one inch per hour. Plastic window may be lifted to write on chart paper.

Figure 2-1. LOCATION AND FUNCTION OF CONTROLS ON FRONT PANEL (Sheet 1 of 2)

(11) Paper Position Adjustment. Allows the recorder chart paper to be set to the desired time. To set time of recording, move thumbwheel in direction of arrow until desired hour appears directly under striker bar that presses stylus against chart paper. The first few hundred serial numbered instruments may contain a lever instead of a thumbwheel. In this case, set time by depressing lever and pulling chart paper until desired hour appears under stricker bar.

(12) METER FUNCTION Switch. Selects meter modes for monitoring instrument operation.

-RF SIGNAL Position - Monitors strength of received signal. Green area indicates adequate signal strength for receiver lock. Yellow area indicates marginal signal strength. When in the yellow area, NO SIGNAL and NO LOCK lights will reveal periods of inadequate signal.

- ALIGN: SERVO PD, SIG PD, and SYNTH Positions - Used to align the SERVO and SIGNAL Phase Detectors and the conversion SYNTHesizer during calibration.

- SERVO PD Position - Meter indicates servo phase detector error voltage and balance. During normal operation, meter needle will vary around center alignment mark. When meter is to left of alignment mark, counter will gain counts. When to the right, it will lose counts. At faster tracking rates (1×10^{-6}, 3×10^{-7}) the meter will move with large jerky excursions. The excursions will be smaller at slower tracking rates due to the longer servo time constant.

- SIG PD Position - Meter indicates signal phase detector balance during calibration. When meter locks on received signal during operation, meter will peg at right end.

- SYNTH Position - Meter indicates in green ALIGN area for all valid frequencies during calibration. When instrument is turned on, meter will jerk into alignment when synthesizer locks onto the frequency set on FREQUENCY/kHz dials.

+ and - PWR Positions - Meter indicates in green POWER area when + and - 13 volt power supply voltages are within tolerance.

(13) RECORDER CAL Switch. Forces conditions of 0 and 100 microseconds for calibration of internal and external recorder outputs.

(14) AUDIO Volume Control. Adjusts internal speaker and front panel phone jack volume of monitored 1.1 kHz if signal.

(15) AUDIO Head Phone Jack. Overrides internal speaker for private monitoring of 1.1 kHz second if signal.

(16) Meter. Indicates reveiver operation according to position of METER FUNCTION switch.

(17) ACCUMULATIVE ERROR Counter Preset Control. Allows ACCUMULATIVE ERROR counter to be preset to any desired value.

(18) ACCUMULATIVE ERROR Counter RESET Button. Used to reset ACCUMULATIVE ERROR counter to zero.

(19) ACCUMULATIVE ERROR Counter. Displays the total relative time (phase) shifts made to the signal from the local primary standard necessary for phase tracking the received standard. The counter accumulates up to 9999.9 microseconds in 0.1 microsecond steps.

(20) ACCUMULATOR Switch. Allows the ACCUMULATIVE ERROR counter to be turned off when not in use.

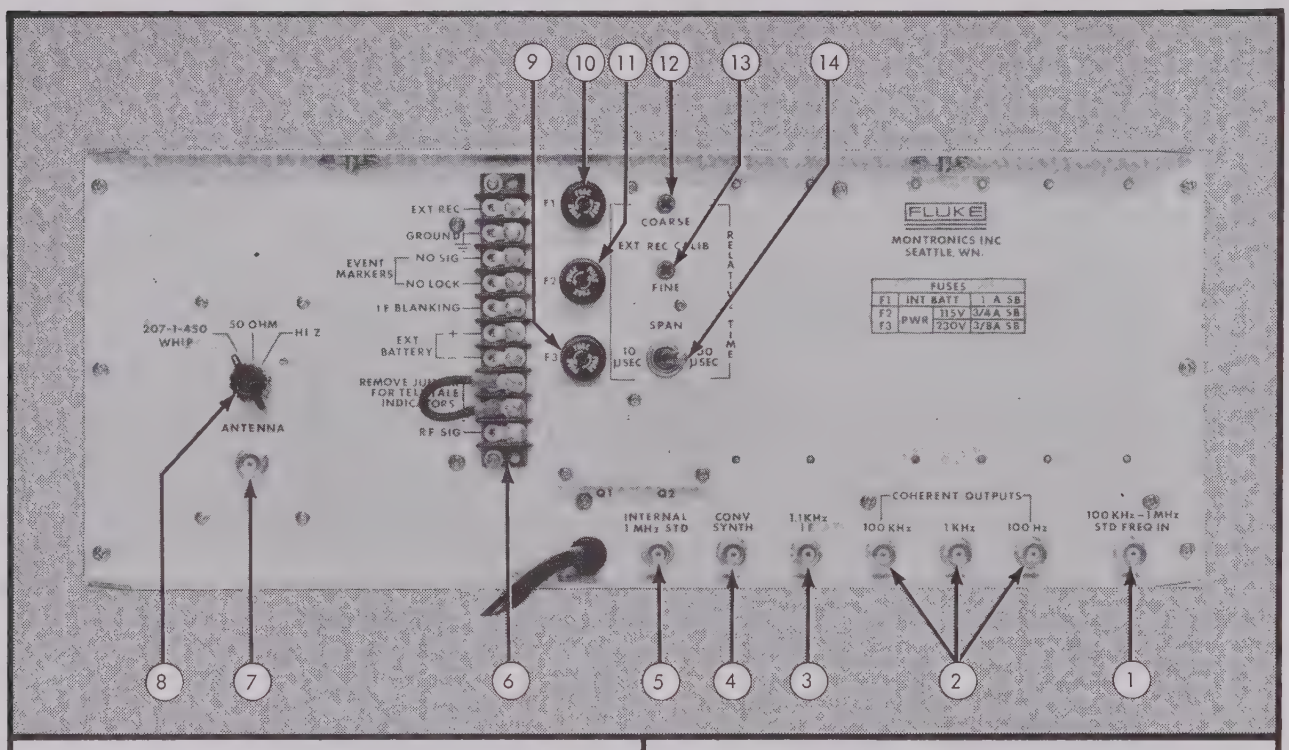
(21) RELATIVE TIME Recorder Knurled Thumb Screw. Allows recorder to be opened for replacing chart paper, adjustments, etc.

(22) FREQUENCY/kHz Dials. Allows selection of any station between 8.0 and 31.9 kHz in 100 Hz increments and stations at 60.0 kHz.

(23) RF ATTENUATOR Switch. Attenuates the antenna input signal from 0 to 60 db in 10 db steps when necessary. This switch is normally set to 0 DECIBELS due to the large (80 db) dynamic range of the receiver. An overload at the antenna input will not introduce appreciable phase shift into the receiver as long as the signal does not vary greatly.

(24) RF FILTER Switch. Selects one of five rf filters. The BROADBAND position is normally used. It passes 8.0 to 31.9 and 60.0 kHz. Positions 1, 2, 3, and 4 select optional plug-in narrowband filters which can be provided for any frequency within the receiver range.

Figure 2-1. LOCATION AND FUNCTION OF CONTROLS ON FRONT PANEL (Sheet 2 of 2)



(1) 100 kHz - 1 MHz STD FREQ IN Connector. Connects to the local primary frequency standard that is to be compared to the received vlf signal. The input signal may be a sine, square, or pulse wave in any 100 kHz increment from 100 kHz to 1 MHz with a peak-to-peak value of 0.3 to 15 volts. The local frequency standard must be within 1 part in 10^6 of its nominal frequency for the receiver to maintain lock.

(2) 100 Hz, 1 KHz, and 100 KHz COHERENT OUTPUTS. Provides outputs of 100 Hz, 1 kHz, and 100 kHz that are coherent (in phase) with the received signal.

(3) 1.1 KHz IF Connector. Provides an isolated 1.1 kHz if output from the IF Amplifier Board.

(4) CONV SYNTH Connector. Provides a square output from the synthesizer that is 51.1 kHz above the received signal.

(5) INTERNAL 1 MHz STD Connector. Provides an output from the 1 MHz frequency standard present in the 207-4, 207-4B, 207-5, and 207-5B.

(6) Terminal Block.

- EXT REC Terminal - Provides current drive for an external relative time recorder. Full scale corresponds to 1 ma for recorders from 0 to 1,000 ohms.

- GROUND Terminal - Allows connections to chassis ground.

- NO SIG EVENT MARKER Terminal - Provides + 13 volts dc when adequate signal is present and 0 volts when adequate signal is not present.

- NO LOCK EVENT MARKER Terminal - Provides +13 volts dc when instrument is phase locked to the received signal and 0 volts when it is not locked.

- IF BLANKING Terminal - Grounding this terminal blanks the if signal after the audio and before the phase detectors. This is used primarily for sequence decoding of Omega transmissions.

- EXT BATTERY + and - Terminals - Connection of +12 and -12 volts dc standby power to these terminals will maintain receiver operation (except 1 MHz standard in 207-4 and 207-5 and RELATIVE TIME recorder) during periods of power failure. Power requirements are approximately 2 amperes for the +12 volt battery and 400 milliamperes for the -12 volt battery.

- TELL-TALE INDICATORS Terminals - When the jumper between these terminals is removed, the NO SIGNAL and NO LOCK light will remain lighted following the appropriate condition until the indicator is PRESSed TO TEST. With the jumper installed, the indicator lights follow the operation of the receiver to indicate adequate signal and phase lock.

Figure 2-2. LOCATION AND FUNCTION OF CONTROLS ON REAR PANEL (Sheet 1 of 2)

- RF SIG Terminal - Provides a 20 db signal output for potentiometeric recording of rf signal strength.

⑦ ANTENNA Connector. Connects to external antenna used for receiving standard frequency broadcasts. For additional antenna information, refer to Antenna Installation procedure in paragraph 2-3.

⑧ ANTENNA Switch. Selects the correct input circuit for the antenna used. See paragraph 2-5 for an explanation of antenna types.

⑨ Fuse F3. A slow blowing 3/4 ampere fuse for 115 volt line operation or 3/8 ampere for 230 volt line operation. Used for overload protection on one side of ac line power.

⑩ Fuse F1. A slow blowing 1 ampere fuse used for overload protection in internal standard rechargeable battery circuit of 207-4B and 207-5B.

⑪ Fuse F2. A slow blowing 3/4 ampere fuse for 115 volt line operation or 3/8 ampere for 230 volt line operation. Used for overload protection on one side of ac line power.

⑫ RELATIVE TIME COARSE EXT REC CALIB Control. Provides coarse adjustment for external recorder output level.

⑬ RELATIVE TIME FINE EXT REC CALIB Control. Provides fine adjustment for external recorder output level.

⑭ RELATIVE TIME SPAN Switch. Selects either 100 USEC or 10 USEC chart span for both the external and internal recorders.

Figure 2-2. LOCATION AND FUNCTION OF CONTROLS ON REAR PANEL (Sheet 2 of 2)

lamp indicates that the receiver sees a lock point and then comes out of lock as the phase of the local frequency standard passes by or falls behind the phase of the received signal.

2-26. METER INDICATIONS. When the Model 207 is operating properly and is locked onto a station, the front-panel meter will indicate proper operation with the METER FUNCTION switch set in the RF SIG, SERVO PD, SIG PD, and SYNTH positions. In the RF SIG position of the METER FUNCTION switch, the meter monitors the strength of the received signal. The green area indicates adequate signal strength for receiver lock and the yellow area indicates marginal signal strength. In the SERVO PD position, the meter indicates servo phase detector error voltage and balance. During normal operation, the meter will vary around the center alignment mark. At wider tracking rates, the meter will move with large jerky excursions. At narrower tracking rates the excursions will be smaller due to the longer time constant of the servo loop. In the SIG PD position, the meter indicates the signal phase detector balance. During normal operation when the receiver is locked onto a station, the meter will peg to the right. In the SYNTH position, the meter will point to the center alignment mark during normal operation.

2-27. SPEAKER INDICATION. When the receiver is operating properly and is locked onto a station, the 1.1 kHz if frequency may be heard at the audio speaker by turning the AUDIO volume control up. The signal heard may also contain any modulation and noise on the vlf signal. However, due to the narrow band width of the servo system, it is possible for the receiver to be operating properly even though no signal can be heard. For private monitoring, the speaker may be overridden by plugging head phones into the AUDIO jack on the front panel.

2-28. VLF STATION SELECTION

2-29. There are a large number of worldwide lf and vlf standard frequency broadcasting stations. Some of these stations are listed in Appendix C along with brief information about their broadcasts. The selection of a particular station will depend upon the local reception characteristics of that station along with the wants and desires of the user. For details about maintenance shutdowns, frequency offsets, etc., write directly to the controlling agency. Notices about the National Bureau of Standards frequency and time stations appear regularly in "NBS Technical News Bulletin" and under "NOTICES... Standard Frequency and Time Notices, National Bureau of Standards" in the PROCEEDING OF THE IEEE. In selecting a vlf station, an understanding of the UT2 and A.1 time scales, the Omega navigational system, and the optional narrow band rf filters may be helpful.

2-30. UT2 and A.1 TIME SCALES. Atomic Time (A.1) is based on the cesium beam atomic frequency standard. This standard was adopted as the standard of frequency and time by international agreement in October 1964. Since that time, the United States frequency standard (USFS) has been based on the A.1 time scale. National Bureau of Standards station WWVB broadcasts a standard frequency at 60 kHz derived directly from the USFS. Thus, users of station WWVB may directly perform absolute frequency comparisons.

2-31. Universal Time (UT) is the time scale ordinarily indicated by clocks and used in daily life. It is based on time intervals derived from the rotation of the earth around the sun. The UT2 time scale is Universal Time that has been corrected for changes in the rotational speed of the earth due to polar motion and seasonal

variations. Even though UT2 represents the mean rotational speed of the earth, it is still not uniform because of progressive changes in the earth's speed of rotation. National Bureau of Standards station WWVL broadcasts a standard frequency at 20 kHz that is intentionally offset from the USFS by a small, but precisely known, amount. This makes available time intervals that are close to the UT2 time scale, which can be accurately determined only by astronomical observations over a period of time. At the beginning of each year, the Bureau International de'l Heure (B. I. H.) announces the fractional frequency offset that will remain in effect for the entire year. An idea of the range of values these fractional frequency offsets may take on can be made by studying the following values:

1959	-170 parts in 10^{10}
1960	-150 parts in 10^{10}
1961	-150 parts in 10^{10}
1962	-130 parts in 10^{10}
1963	-130 parts in 10^{10}
1964	-150 parts in 10^{10}
1965	-150 parts in 10^{10}
1966	-300 parts in 10^{10}
1967	-300 parts in 10^{10}

2-32. A local frequency standard may be set to either the A. 1 or UT2 time scales. At this time, most frequency standard stations transmit on the UT2 time scale. In addition, all sources of time of day information, as opposed to time interval information, such as telephone companys, Western Union, etc., operate on the UT2 time scale. For these reasons, most people calibrate their local frequency standard to UT2 time. However, if there is a need for a frequency standard based on the A. 1 time scale, station WWVB at 60 kHz may be used. The important thing to keep in mind is the offset between the A. 1 and UT2 time scales. In 1967, the difference is 300 parts in 10^{10} or 3 parts in 10^{8}. This means phase records made on the 20 kHz station and 60 kHz station will differ by 3 parts in 10^{8}.

2-33. OMEGA NAVIGATIONAL SYSTEM. The United States Navy is now perfecting the vlf Omega navigational system. This system will have worldwide coverage with only eight stations broadcasting on the same frequency with a time shared format. At any one place on earth, the signals from at least three of the eight stations can be received. By measuring of time-shared vlf transmissions, a geographical fix may be obtained from the resulting hyperbolic lines of position. The accuracy of this system will be about 1/2 nautical mile.

2-34. Although Omega broadcasts are intended for navigation, they will become a method of distributing standard frequencies. In order to use the Omega broadcasts with a vlf receiver, the receiver will have to be blanked during 7 of the 8 transmission periods. For this purpose, the 207 receiver is provided with IF BLANKING terminals, Grounding these terminals during undesired periods of transmission blanks the if signal and locks out the phase shifter.

2-35. NARROW BAND RF FILTERS. To provide increased rejection of very strong adjacent frequencies, narrow band rf filters are available. Each rf filter, tuned for a specific frequency, is contained on a printed circuit board that plugs into the receiver. The receiver will accept up to four narrow band rf filters. Any one of these may be placed in series with the broadband filter by the use of the front-panel RF FILTER switch. These filters are normally not required.

2-36. TRACKING RATE SELECTION

2-37. The TRACKING RATE switch allows selection of four time constants (band widths) for the servo phase detector and four clock rates for the phase shifter. Tracking rates of 1 part in 10^{6}, 3 parts in 10^{7}, 1 part in 10^{7}, and 3 parts in 10^{8} are available. It is obvious that a wider tracking rate, such as 1 part in 10^{6}, is useful for measuring local frequency standards that are not stable or have not been calibrated for a long time. However, it is not obvious that narrower rates allow short-term propagation instabilities of the received signal and noise to be averaged out.

2-38. NOISE AVERAGING. The receiver is capable of tracking a received signal 50 db below the noise level (gaussian noise measured in a 1 kHz bandwidth). Tracking a signal under these conditions requires the operational integrator of the phase detector to have a time constant much larger than the period of the 1. 1 kHz waveform derived from the received signal. These long time constants allow the operational integrator to act as a low pass filter. Thus, phase instabilities of the received signal and noise are averaged out. A typical signal on the 1 part in 10^{6} tracking rate will have noise of 6 to 8 or more microseconds. Minimum noise is obtained at a tracking rate of 3 parts in 10^{8} which corresponds to the longest time constant.

2-39. SUGGESTED PROCEDURE. To obtain the smoothest noise free trace, it is desirable to operate the receiver at the narrowest tracking rate of 3 parts in 10^{8}. However, if the local frequency standard is off by more than 3 parts in 10^{8} or its stability is such that frequency excursions cause the local frequency standard to be off by more than 3 parts in 10^{8} at certain times, the receiver can not follow the local standard. This will cause the receiver to unlock at times resulting in a confusing recording. In addition, if the diurnal shift at the receiver location is large and occurs over a short period of time, it may cause the receiver to unlock when the tracking rate is too narrow. In the United States, it is suggested that the 1 part in 10^{7} tracking rate be used at first. If experience shows that the diurnal shifts occur at a rate slower than 3 parts in 10^{8}, the 3 parts in 10^{8} tracking rate may be used.

2-40. MEASUREMENT PERIOD SELECTION

2-41. In general, the greater the desired accuracy for a frequency comparison, the longer the comparison period must be. Typical noon-to-noon prapagation uncertainty is a few microseconds. The uncertainty of the 207 receiver is better than ±1 microsecond for a 24 hour period as long as the temperature is maintained within ±5° C. Good laboratory practice dictates that the

total uncertainty be less than the error due to the frequency offset. As a result, a comparison within 1 part in 10^8 requires about 15 minutes and a comparison within 1 part in 10^9 typically requires a few hours.

2-42. DAY-TO-DAY ACCURACY. It is often said that vlf frequency comparisons have an attainable day-to-day accuracy of 1 part in 10^{11}. However, this refers only to the propagation instability between the transmitter and the receiver under favorable conditions. Due to unknown atmospheric disturbances, the propagation uncertainty should be taken as 2 to 3 parts in 10^{11}. To this, the uncertainty of the Model 207 receiver (less than 1 part in 10^{11}) and the uncertainty of the transmitted frequency (within 2 x 10^{11} for NBS stations WWVL and WWVB) must be added. The total uncertainty is thus about 5 parts in 10^{11}. Since it is unlikely that all the factors are at their maximum at the same time, a more realistic uncertainty is given by the square root of the sum of the squares of the uncertainties. This gives about 3.32 parts in 10^{11} or an accuracy of a few parts in 10^{11} for a 24 hour period. For best accuracy, 24 hour measurements should be made from noon to noon to cancel out diurnal shifts (see paragraph 2-63) and to avoid the greater propagation instabilities that occur at night.

2-43. LONG MEASUREMENT PERIODS. Accuracies greater than a few parts in 10^{11} may be obtained by making comparisons over an integral number of noon-to-noon days. In this case, the Monthly Fractional Frequency Offset Tables published by NBS for stations WWVB and WWVL must be used to obtain an improvement in accuracy. Also, when making higher accuracy comparisons, the frequency offset at any particular time is still unknown. The frequency offset obtained is the average frequency offset over the observation period.

2-44. NORMAL OPERATION

2-45. COMPARING A LOCAL FREQUENCY STANDARD TO A RECEIVED VLF SIGNAL

a. Make sure vlf receiver has been prepared for use as instructed in paragraph 2-1.

b. Set switches on vlf receiver as follows:

SPAN	100 USEC or 10 USEC
RF ATTENUATION	0 DECIBELS
RF FILTER	BROADBAND
TRACKING RATE	1 x 10^{-6}
ACCUMULATOR	ON
FREQUENCY/KHz	To desired station

c. Move RELATIVE TIME recorder thumbwheel in direction of arrow until desired hour appears under striker bar that presses stylus against chart paper. If vlf receiver contains a lever in place of a thumbwheel, set time by depressing lever and pulling chart paper until desired hour appears under striker bar.

d. Either reset ACCUMULATIVE ERROR counter to zero with RESET button, preset to desired value with counter preset control, or set ACCUMULATOR to OFF.

e. Set POWER switch to the on position. The POWER indicator lamp will illuminate.

f. As soon as the NO LOCK and NO SIGNAL indicator lamps go out, the vlf receiver is comparing the local frequency standard to the received vlf signal.

g. Set TRACKING RATE switch to as slow a tracking rate as allowed by the local frequency standard offset.

h. When sufficient information is obtained, interpret data as instructed in paragraph 2-49.

2-46. COMPARING TWO LOCAL FREQUENCY STANDARDS

2-47. OPTIONAL COMPARISON FREQUENCY INPUT. Standard option Models 207-3, 207-5, and 207-5B allow a secondary local frequency standard to be compared to the primary local frequency standard. To make this comparison, the signal to be compared to the primary standard is applied to a front-panel BNC connector. This signal automatically disables the rf section of the receiver and indicates this mode of operation by the illumination of the NO SIGNAL lamp. The relative phase comparison between the secondary standard and the primary standard may then be read directly from the RELATIVE TIME recorder in the same manner as when the primary standard is compared to the received vlf signal. Removal of the secondary standard returns the receiver to normal operation. The RELATIVE TIME recorder will resume the previous comparison between the primary standard and the received vlf signal without loss of phase information as long as they have not changed in phase by more than ±180° during the period of measurement.

2-48. USING COMPARISON FREQUENCY INPUT. To use the optional frequency comparitor, proceed as follows:

a. Complete procedure of paragraph 2-45 as if comparing the local primary frequency standard to a received vlf signal.

b. Connect local secondary frequency standard to COMPARISON INPUT connector. The NO SIGNAL lamp will illuminate and remain on as an indication of this mode of operation. The local secondary frequency standard must be a sine, square, or pulse waveform of 100 kHz to 1 MHz in any 100 kHz multiple with a peak-to-peak value of 0.3 to 15.0 volts.

c. Interpret data as instructed in paragraph 2-49. Note that when comparing to another local standard instead of a received vlf signal, the recorder comparison plot will be much smoother. This is due to absence of noise, propagation instability, and diurnal shift associated with vlf signals that are broadcast.

d. Disconnect local secondary frequency standard from COMPARISON INPUT connector when desired data is obtained. The vlf receiver will return to normal operation comparing the local primary standard to the received vlf signal. The RELATIVE TIME RECORDER will resume the previous comparison without loss of phase information as long as the phase between the primary frequency standard and the received vlf signal has not changed by more than ±180° during the period of measurement.

2-49. DATA INTERPRETATION

2-50. In order to interpret the data, it is necessary to consider the sources of the data, the measurement of the data, and the vlf propagation phenomena which affect the data.

2-51. DATA SOURCES

2-52. RELATIVE TIME RECORDER. The slope of the RELATIVE TIME chart recording represnets the frequency offset between the local frequency standard and the received vlf signal. The RELATIVE TIME recorder plots the phase difference between two 10 kHz (or 100 kHz for 10 microseconds full scale) square waves. One square wave is derived from the local frequency standard while the other is phased locked to the received vlf signal. Since the recorder chart paper moves at a constant rate of 1 inch per hour, the recorder traces out phase changes in microseconds accumulated over a definite elapsed time period. The slope is thus a ratio of relative time changes to actual time. Since frequency is the reciprical of a time interval, the fractional frequency error of the local standard is equal to the fractional time error.

2-53. ACCUMULATIVE ERROR COUNTER. The ACCUMULATIVE ERROR counter counts each 0.1 microsecond phase shift added or deleted by the phase shifter. This counter thus gives the same information as the RELATIVE TIME recorder except that there is no continuous history short of constantly watching the counter. Normally, the ACCUMULATIVE ERROR counter is used only when resolution higher than can be obtained from the RELATIVE TIME recorder is required. In this case, the ACCUMULATIVE ERROR counter and the RELATIVE TIME recorder are used together to provide higher resolution and a permanent record. In use, the ACCUMULATIVE ERROR counter may be preset to match the RELATIVE TIME recorder or set to zero at the start of the test period. The counter will accumulate up to 100 sweeps of the chart recording for the 100 microsecond span. When the local frequency standard is high in frequency, the counter will add time as the phase shifts. When the local frequency standard is low in frequency, the counter will subtract time.

2-54. DATA MEASUREMENT

2-55. Two types of information are generally sought about a local frequency standard: (1) the frequency offset, and (2) the rate of change of frequency offset (frequency drift rate). To determine the frequency drift rate, the fractional frequency offset ($\triangle F/F$) must be known at two different times (T_1 and T_2). The difference in the slop of the trace at the two times thus gives the drift rate

$$d = \frac{\triangle F_2}{F_2} - \frac{\triangle F_1}{F_1}$$

For example, if the fractional frequency offset is 2.3×10^{-9} at noon on one day and 3.1×10^{-9} at noon the next day, the drift rate is $(3.1 \times 10^{-9}) - (2.3 \times 10^{-9}) = 0.8 \times 10^{-9}$ or +8 parts in 10^{10} per day. The frequency offset may be determined by three methods: (1) the plastic overlay method, (2) the graphical method, and (3) the direct mathematical method.

2-56. PLASTIC OVERLAY METHOD. There are two procedures of using the plastic overlay. To use the first procedure, place chart recording perforations on the left and align long lines at edges of plastic overlay with lines at edges of chart recording. Then, move overlay along recording until small circle along center line is directly over the recorder curve as shown in Figure 2-3. The fractional frequency offset (deviation) may then be read directly from the overlay. In the example of Figure 2-3, the local frequency standard is 3.0 parts in 10^8 lower in frequency than the received vlf signal. Note that the sign of the frequency offset is determined by the direction of the slope of the recording. A positive slope (from left to right uphill) indicates that the local frequency standard is high in frequency. Similarly, a negative slope (left to right downhill) indicates that the local frequency standard is low in frequency. Also note that the plastic overlay gives frequency offset for both 100 and 10 microsecond spans with the value for the 10 microsecond span given in parenthesis.

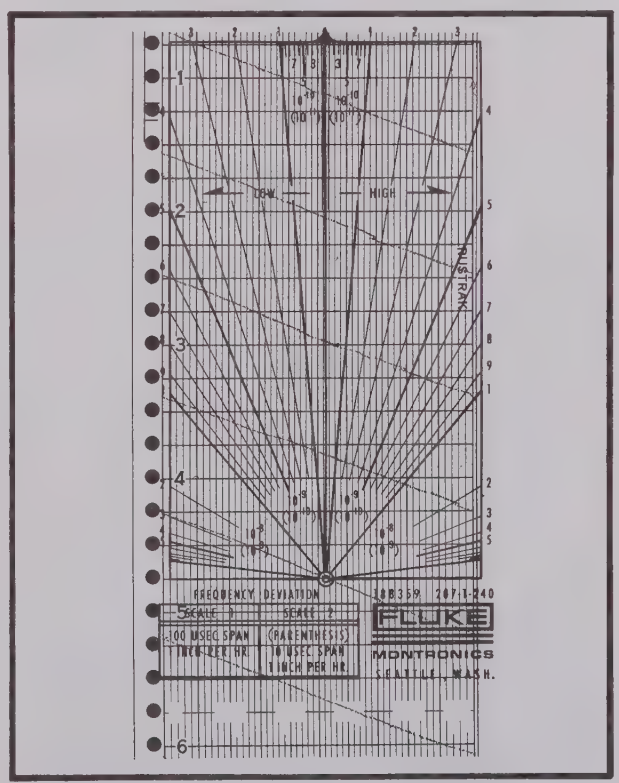


Figure 2-3. FIRST PROCEDURE FOR USING PLASTIC OVERLAY

2-57. To use the second procedure, align plastic overlay so that long lines at edges of overlay are parallel to edges of the recording and one of the frequency deviation lines is tangent to recorded curve at desired time. In the example of Figure 2-4, the local frequency standard is 9 parts in 10^{10} higher than the received signal at 8 o'clock.

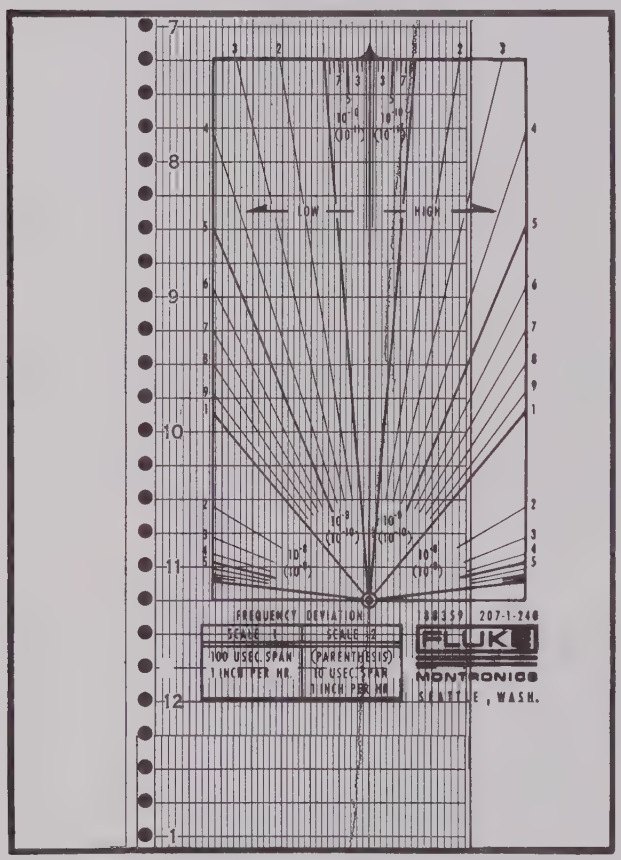


Figure 2-4. SECOND PROCEDURE FOR USING PLASTIC OVERLAY

2-58. GRAPHICAL METHOD. Two graphical procedures are given here for determining the fractional frequency offset. For the first procedure, Figure 2-6 gives the fractional frequency offset as a function of observation period with an accumulative offset of 100 microseconds (or 10 microseconds). For example, the chart recording of Figure 2-5 has a negative slope indicating that the local frequency standard is low in frequency. Using the time between the beginning and the end of the sweep, 2-1/2 hours, a fractional frequency offset of 1.1 parts in 10^8 is obtained from Figures 2-6 by going from 2.5 on the observation period in hours line to the fractional frequency offset line.

2-59. For the second procedure, Figure 2-7 gives the fractional frequency offset as a function of accumulative offset for various fixed observation periods. For example, in the chart recording of Figure 2-4, 21 microseconds was accumulated in an observation period of 6 hours (7 am to 1 pm). Using the 21 microseconds of offset accumulated in 6 hours, a fractional frequency offset of 9.7 parts in 10^{10} is obtained from Figure 2-7.

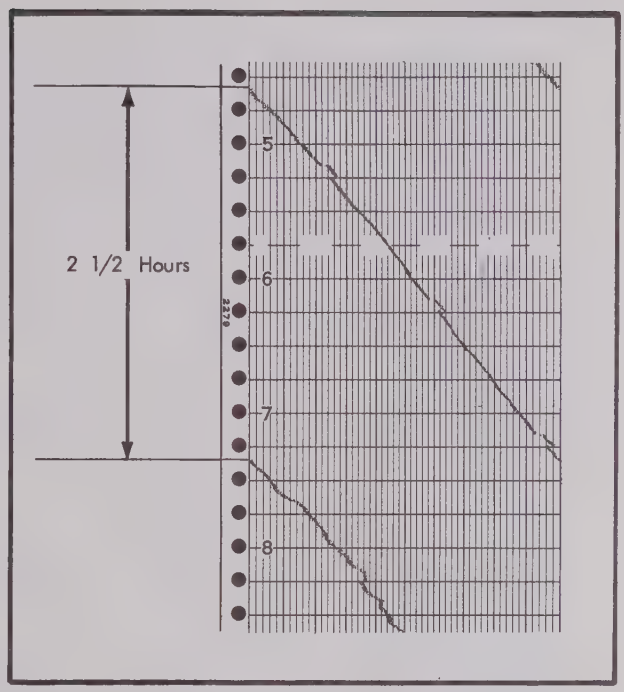


Figure 2-5. CHART RECORDING USED IN EXAMPLE FOR DETERMINING FRACTIONAL FREQUENCY OFFSET WITH THE CHART OF FIGURE 2-6

2-60. MATHEMATICAL METHOD. The fractional frequency offset is equal to the fractional time offset. Therefore, the average frequency offset ($\triangle F/F$) of the local frequency standard over an observation period may be calculated from the following equation:

$$\frac{\triangle F}{F} = \frac{\triangle T}{T}$$

Where:

F = frequency of received vlf signal in Hertz.
$\triangle F$ = frequency offset of local standard from received vlf signal in Hertz.
$\triangle T$ = accumulative time offset.
T = observation period required to accumulate the time offset.

For example, the 100 microseconds accumulated in 2-1/2 hours for Figure 2-5 gives a fractional frequency offset of

$$\frac{\triangle F}{F} = \frac{100 \text{ usec}}{2.5 \text{ hrs}} \times \frac{1 \text{ hr}}{3600 \text{ sec}} = 1.11 \text{ parts in } 10^8$$

2-61. VLF PROPAGATION PHENOMENA

2-62. The propagation and reception of vlf signals is a complex subject. At this time there is a limited amount of reliable technical information about vlf phenomena. Thus, the theoretical reasons given here for

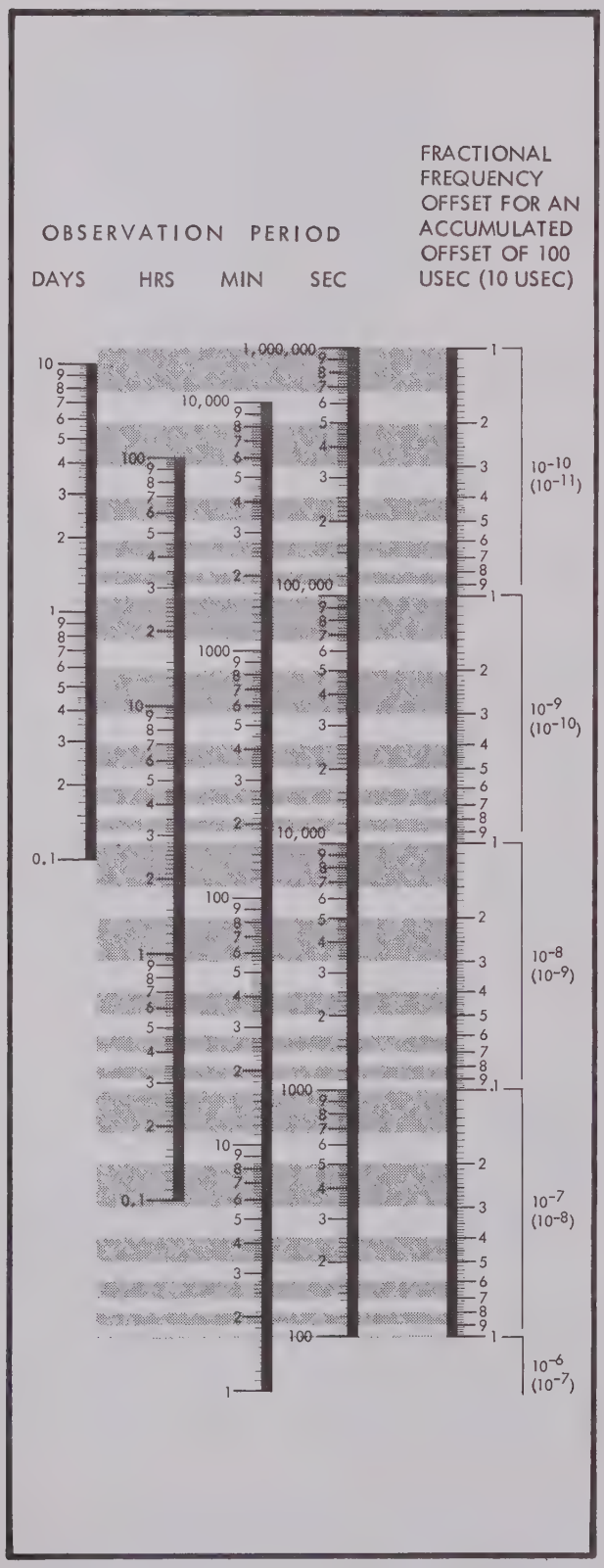


Figure 2-6. FRACTIONAL FREQUENCY OFFSET AS A FUNCTION OF OBSERVATION PERIOD WITH AN ACCUMULATIVE OFFSET OF 100 USEC (OR 10 USEC)

certain vlf phenomena are subject to change as the understanding of this field increases. However, the information given here on diurnal shift, reverse diurnal shift, and gain or loss of a cycle will provide a helpful starting point for learning more about the interpretation of vlf phase plots.

2-63. DIURNAL SHIFT. Diurnal shift is the shift in phase of the received vlf signal that occurs during sunrise and sunset. To better understand this phenomenon, assume that the vlf signal is propagated through a waveguide bounded by the earth and the ionospheric layers. When the sun comes up in the morning, the ionospheric layers become more fully ionized by the incident energy from the sunlight. This increase in ionization effectively lowers the height of the ionospheric layer. The wave which has been reflected at least one or more times from the ionospheric layer, will thus have a smaller distance to travel between the transmitter and the receiver. This decreased path length causes the vlf signal to advance in phase at the receiver relative to its condition during the night. The local frequency standard will then appear to be decreasing in frequency (5:40 to 6:35 am in Figure 2-8) during the sunrise diurnal shift. Similarly, the local frequency standard will appear to be increasing in frequency during sunset when the ionospheric layers are rising.

2-64. The amount of diurnal shift and the period of time over which it occurs is dependent on the relative location of the transmitter and receiver. Typical diurnal shifts are from 20 to 50 microseconds. However, in certain cases no diurnal shift may occur. Generally, the dirunal shift time period will be equal to the time it takes the sun to traverse the distance between the transmitter and receiver. For example, if the sunset begins in Boulder, Colorado about 2 hours before it begins in San Francisco, California, the diurnal shift will last about 2 hours for a signal transmitted from Boulder to San Francisco. Similarly, the diurnal shift of station GBR, transmitted from the south coast of England, will be about 9 or 10 hours for a signal received in Seattle, Washington. A receiver located on a north-south line with the transmitter will experience an abrupt diurnal shift which may cause the receiver to unlock when narrow tracking rates are used.

2-65. Diurnal shift need not cause any error in frequency comparison measurements. Obviously, meaningful measurements can not be made during periods of diurnal shift or between two times including one diurnal shift. However, when measurements are made from noon one day to noon the next day, there will be negligible phase shift in the received signal except for seasonal variations.

2-66. REVERSE DIURNAL SHIFT. In some locations, reverse diurnal shifts have been observed from time to time. If we assume that vlf propagation is possible by

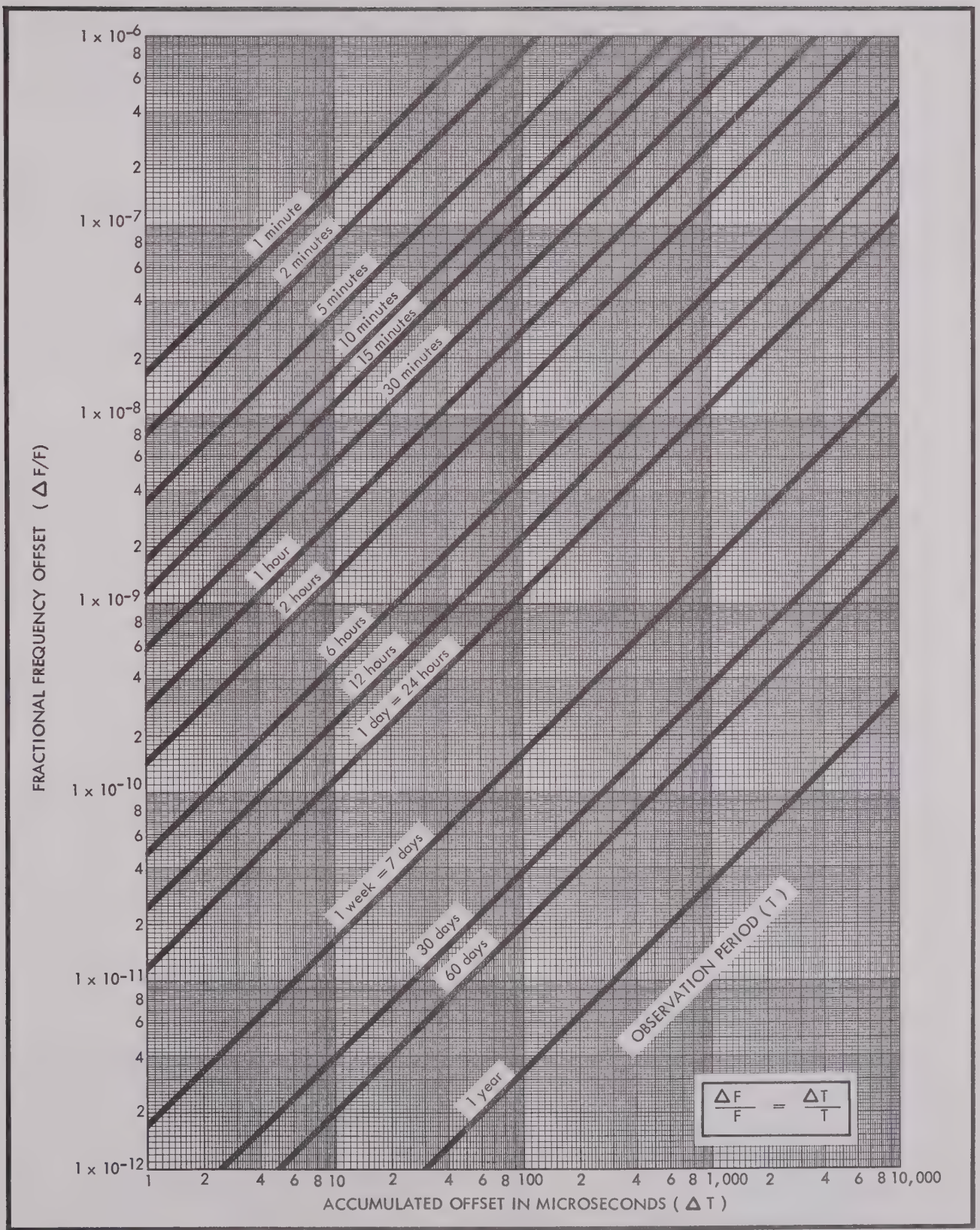


Figure 2-7. FRACTIONAL FREQUENCY OFFSET AS A FUNCTION OF ACCUMULATIVE OFFSET ΔT IN OBSERVATION PERIOD T

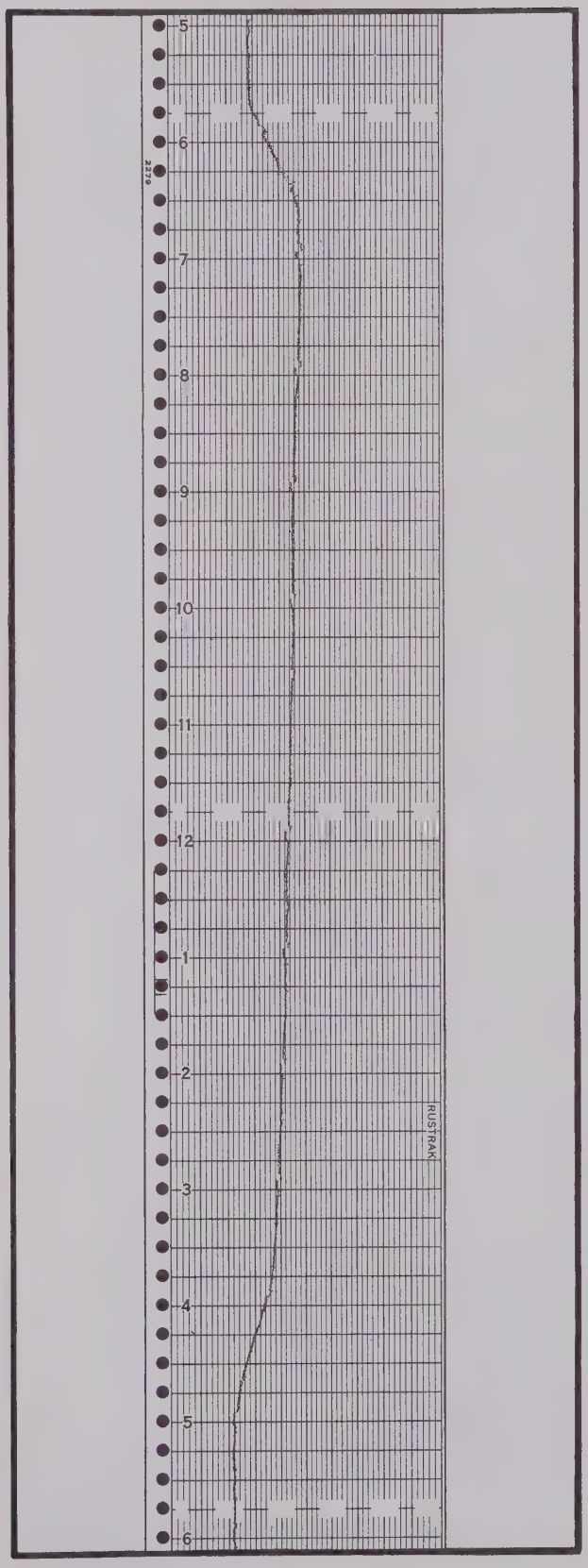


Figure 2-8. DIURNAL SHIFT ON A RELATIVE TIME CHART RECORDING

both groundwave and skywave, reverse diurnal shift can be explained by the possibility of the groundwave and skywave amplitudes interchanging from time to time. Simply knowing this can occur allows measurements to be made without any unnecessary concern over this anomaly.

2-67. GAIN OR LOSS OF A CYCLE. Gain or loss of a cycle refers to the phenomenon where the received signal occasionally advances or retards by a full 360° phase shift. This phenomenon usually occurs during a diurnal shift period. It is thought to occur due to interference between energy components arriving from the transmitter along different paths. These signals can cancel and almost instantaneously change phase by 180°. Since a vlf receiver does not know which way to catch up to this rapidly changing signal, it appears to gain or lose a full cycle of the received signal.

2-68. The gain or loss of a cycle is only mildly disturbing when making frequency comparisons with a very stable frequency standard. It is easy to recognize because it always occurs in an integral number of cycles. For example, a full cycle gain when receiving 20 kHz is exactly 50 microseconds. With 60 kHz, it is exactly 16-2/3 microseconds. The operator just subtracts or adds the appropriate number of microseconds phase shift to compensate for the gain or loss.

2-69. LOADING CHART PAPER

a. Unscrew knurled thumb screw at upper left corner of recorder and swing recorder out from vlf receiver.

b. Release friction roller assembly by moving it upward to the open position. (See Figure 2-9.)

c. Push two retaining clips up and remove empty supply spool from its slots.

d. Place new roll of chart paper on supply spool so that perforations in paper are adjacent to knorled sholder on supply spool.

e. Remove masking tape and roll out approximately 8 inches of paper from new supply roll with back (dark) side up.

f. Using both hands, slide loop of paper into recorder with an angular motion between friction roller and tension roller, between pointer guard and right side plate, and around drive drum so that holes in paper engage sprockets on drive drum.

g. Depress brake and insert supply spool end pivots into upper two slots on metal frame while taking up excess of chart paper loop. Release brake.

h. Push two retaining clips down, locking supply roll in place.

i. Pull chart paper snug and engage friction roller assembly by moving it down into the lock position.

j. Swing recorder back into vlf receiver, engage knurled thumb screw, and tighten.

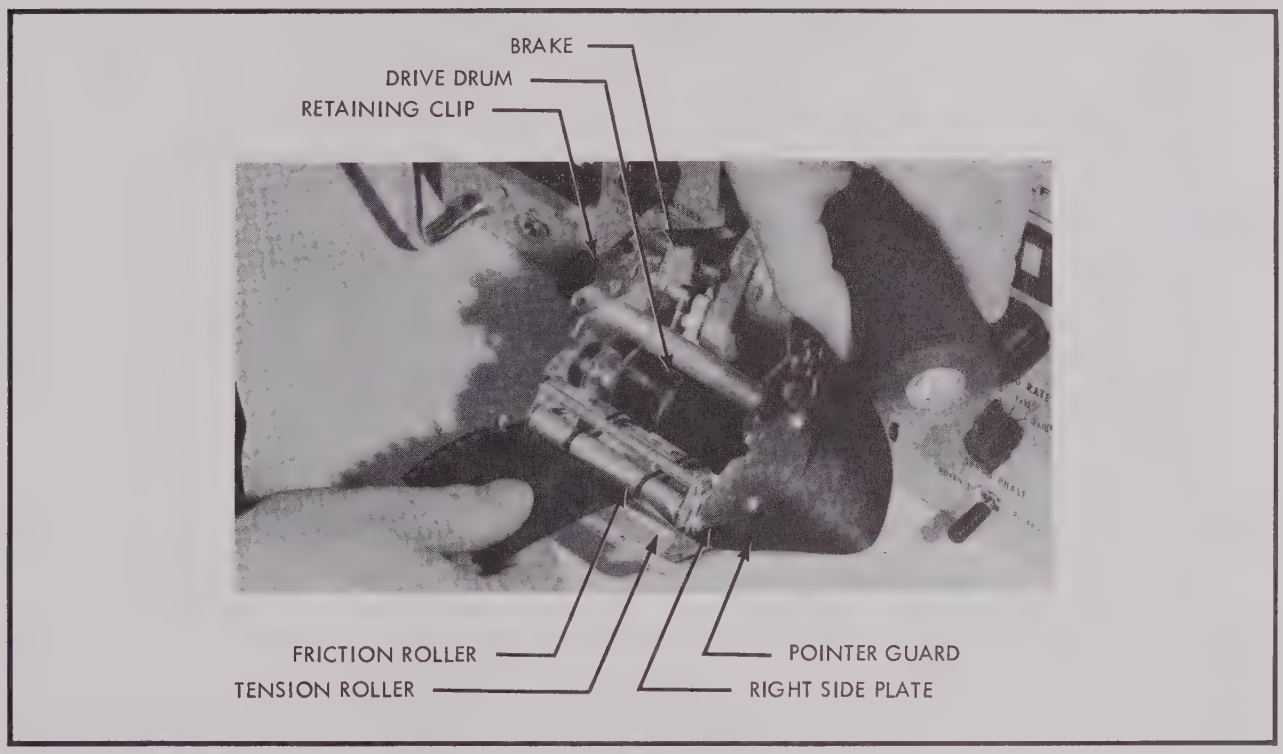


Figure 2-9. LOADING CHART PAPER INTO RECORDER

SECTION III

THEORY OF OPERATION

3-1. INTRODUCTION

3-2. INTEGRATED CIRCUITS

3-3. Throughout the Model 207, Integrated Circuit (IC) components are used to perform certain circuit functions. The symbols used to denote these devices are illustrated in Figure 3-1. Detailed descriptions of their operation are contained in Appendix B of Section VI.

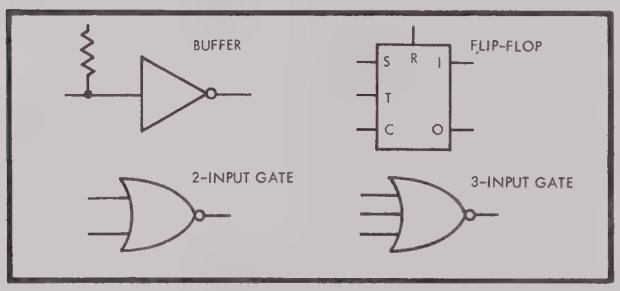


Figure 3-1. INTEGRATED-CIRCUIT COMPONENT SYMBOLS

3-4. The IC Buffer is an inverting current amplifier. A positive-going input signal will result in a negative-going signal at the output. The resistor at the input is used to bias the input circuits. The operation of the 2- and 3-Input Gates may be summarized as follows: a high input state (H) at any of the input terminals will result in a low output state at the output terminal. The exact operating characteristics are summarized in the truth table of Figure 3-2. Typically, the high state is 2.6 volts and the low state is 0.3 volts.

3-INPUT GATE				2-INPUT GATE		
INPUTS			OUTPUT	INPUTS		OUTPUT
1	2	3		1	2	
H	H	H	L	H	H	L
H	H	L	L	H	L	L
H	L	H	L	L	H	L
L	H	H	L	L	L	H
H	L	L	L			
L	H	L	L			
L	L	H	L			
L	L	L	H			

Figure 3-2. SUMMARY OF IC GATE OPERATIONS

3-5. The operation of the IC Flip-Flop is only slightly more complicated than that of the gate. Basic to the operation of the flip-flop is a negative-going transition of the input voltage at the Trigger (T) terminal. This signal triggers the flip-flop output voltages to a state determined by (1) the output voltages before triggering and/or (2) the input voltages at the Set (S) and Clear (C) terminals. The table of Figure 3-3 summarizes the possible output conditions at output 1 following the application of a triggering signal. The notation X^n in the first line indicates that the output voltages remain the same as they were before the application of the triggering signal. The notation X^n in the last line indicates that the output conditions are the inverse (complement) of the state before triggering. For example, if output 1 is high (H) before triggering, it will be low (L) after triggering. Note that the output conditions at terminal 0 are not tabulated in the table. Output 0 is always the inverse of output 1. Another terminal not described in the table is the Reset (R) connection. When this input is activated by a relatively high (H) voltage, output 1 immediately switches to its low state if it is not already there. This occurs without benefit of a triggering signal.

Input at t=n		Output at t=n+1
SET	CLEAR	OUTPUT 1
H	H	X^n
L	H	L
H	L	H
L	L	X^n

Figure 3-3. IC FLIP-FLOP LOGIC LEVELS

3-6. DESCRIPTIVE NOMENCLATURE

3-7. This section of the instruction manual includes circuit descriptions that apply to the Model 207-1, 207-3, 207-4 and 207-5. When it is necessary to refer to all instruments as a group, the term "Model 207" is used. For specific instrument references, the exact model number is used. Each of the assemblies in the instruments have three identifying numbers. One is the schematic diagram reference designation. It consists of the letter A followed by one or two digits (e.g. A4). The second is a stock number for ordering replacement parts. It is a ten-digit number (e.g. 1702-191460) and

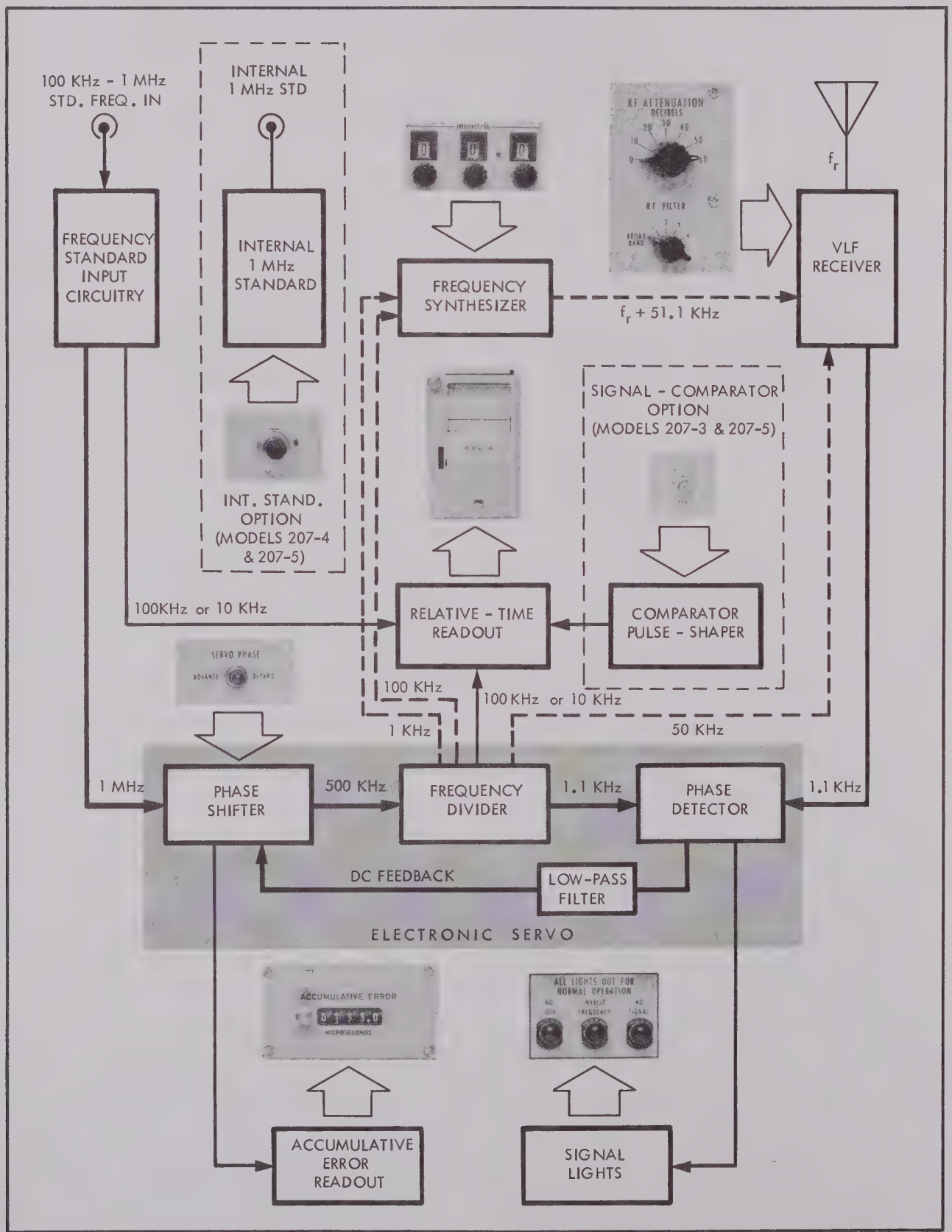


Figure 3-4. SIMPLIFIED BLOCK DIAGRAM WITH RELATED FRONT PANEL CONTROLS AND INDICATORS

should always be specified when ordering replacement parts from the factory. The third is a manufacturing part number. It is a seven-digit number (e.g. 207-1-401) used to identify the assembly during production. Associated with this number are two other numbers. One is a part number for the printed circuit board and the other is the schematic diagram drawing number. The printed circuit board number is characterized by a 3 instead of a 4 as the fifth digit. And, similarily, the drawing number is characterized by a 1 instead of a 4. For example, the Phase Detector Assembly is identified by part number 207-1-401. The printed circuit board on which the components are mounted is identified by 207-1-301. And the schematic diagram Drawing No. is 207-1-101.

3-8. When communicating with Montronics Inc. or their representatives, components can be uniquely identified by complete reference designation. This number consists of the instrument model number, the assembly reference designation and the component reference designation. For example, the number 207-1-A4-R4 uniquely identifies a 4.22 kilohm resistor (R4) on the Phase Detector Assembly (A4) of the Model 207-1.

3-9. Schematic diagrams for all circuits are contained in Section IX. They are arranged in ascending order of drawing number. Sometimes, portions of other assemblies are shown on a schematic for clarity. These circuits are enclosed within dashed lines and referenced to the assembly of which they are located.

3-10. SYSTEM CONCEPTS

3-11. INTRODUCTION

3-12. The overall function of the Model 207 is to provide an accurate indication of time difference between a local frequency standard and a broadcast frequency standard. To this end, the system derives a signal from the local frequency standard, compares it to the broadcast frequency standard and phase-shifts it to maintain coherence with the broadcast signal. Coincidentally, metering circuits measure the time difference between the coherent, generated signal and the local frequency standard. In the paragraphs that follow, the three principle signal paths are considered. To facilitate explanation, the system elements have been simplified to the block diagram of Figure 3-4. A complete and all-encompassing block diagram is contained in Section IX. In Figure 3-4, the signal-comparison signal path is depicted with a heavy, black line. Lighter lines depict the front-panel readout signal paths. And dashed lines depict internal, coherent-signal distribution.

3-13. THE SIGNAL-COMPARISON SIGNAL PATH

3-14. The local frequency standard signal is introduced to the comparator circuits through a rear-panel connector. In the Models 207-4 and 207-5, the optional Internal Frequency Standard can be connected to this input with a short coaxial cable. The frequency standard signal can be any 100 kHz increment in the frequency range from 100 kHz to 1 MHz. In the pulse shaper circuits, it is standardized to a 1 MHz square wave.

3-15. The broadcast frequency standard is received by a vlf superhetrodyne receiver employing double conversion. The first conversion occurs when the frequency synthesizer output (f_r + 51.1 kHz) is mixed with the received signal (f_r). The difference between the two signals, 51.1 kHz, is then mixed with a 50 kHz signal to accomplish the second conversion.

3-16. The function of the Electronic Servo is to (1) generate a 1.1 kHz signal from the 1 MHz local frequency standard, (2) compare the signal with the broadcast standard and (3) maintain a fixed phase relationship between the generated signal and the broadcast frequency standard. The principle circuit elements are depicted inside the shaded area of Figure 3-4. The 1 MHz square wave derived from the local frequency standard drives the phase shifter circuits. Here the frequency is divided by two and the 500 kHz output signal is divided further in the Frequency Divider. The principle Frequency-Divider output signal is a 1.1 kHz square wave. It is compared to the vlf receiver output signal in the Phase Detector. Phase differences between the receiver output and the generated signal result in a dc feedback signal to the Phase Shifter. The phase of the 500 kHz output signal is advanced or retarded in 180° (1 usec) increments to maintain zero phase difference at the Phase Detector.

3-17. THE FRONT-PANEL READOUT SIGNAL PATHS

3-18. There are three types of data readout on the front panel. One is a digital readout of accumulated timing error. The second is a strip-chart recording of frequency offset and the third is a panel-light indication of correct system operation.

3-19. The accumulated timing error information is derived from the Electronic-Servo Phase Shifter. As the Phase Shifter advances or retards the phase of the 500 kHz output signal, each change is recorded on a mechanical counter. The resulting tally on the ACCUMULATIVE ERROR dial is a total count of the phase-shift increments necessary to maintain zero phase shift at the Phase Detector.

3-20. The strip-chart recorder indicates the relative time difference between signals derived from the local frequency standard and the Electronic Servo. The recorder is calibrated for 100-usecond full-scale deflection and for 10-usecond full-scale deflection. The choice of time scale is effected with a switch on the rear panel. When the switch is set for 10 useconds, the frequency of the compared signals is 100 kHz. When the switch is set for 100 useconds, the frequency is 10 kHz. Because the Electronic Servo maintains zero phase difference between the received signal and the Frequency Divider output, the 100 kHz output is coherent with the received signal. Consequently, time differences between this signal and the local frequency standard are a measure of the time difference between the two frequency standards. In the Models 207-3 and 207-5, other local signals can be compared to the local frequency standard. The optional signal-comparator permits connecting a signal source to the front-panel COMPARISON INPUT for direct comparison in the relative-time read-

out circuits. During this operation, the frequency divider circuits are automatically disconnected from the readout circuits.

3-21. Three front-panel indicator lamps signal incorrect system operation when illuminated. The INVALID FREQUENCY lamp is energized by incorrect settings of the FREQUENCY/KHz dials (not illustrated in Figure 3-4). The NO LOCK and NO SIGNAL indicators are energized by logic circuits associated with the Phase Detector.

3-22. INTERNAL COHERENT-SIGNAL DISTRIBUTION

3-23. The Frequency Divider generates several output signals in addition to the 1.1 kHz for phase comparison. Some of them are available at connectors on the rear panel (COHERENT OUTPUTS). Others are connected to internal circuits to effect correct system operation. Because these signals are derived from a common source, they are coherent. This is particularly important in the vlf receiver. Recall that the received signal must pass through two frequency conversions in the receiver. To preserve the phasing of the received signal, it is imperative that the local conversion signals maintain a constant phase relationship.

3-24. FREQUENCY STANDARD INPUT CIRCUITS

3-25. OPTIONAL FREQUENCY STANDARD

3-26. The Models 207-4 and 207-5 include an accurate 1 MHz frequency standard. The unit is depicted as assembly A15 on the Interconnecting Block Diagram of Section IX (Drawing No. 207-1-100). The assembly contains a temperature-controlled crystal oscillator with power and signal connections brought out to a standare 8-pin octal plug, P10. The oscillator includes a varactor in the tuned circuit for effecting minor adjustment of the output frequency. The dc connections to the varactor are acheived through pins 6 and 8 of P10. As shown schematically on the Power Supply and Distribution Schematic (Drawing No. 207-1-106), the control voltage is adjusted by a front-panel 10-turn helipot dial (R5). This permits accurate, vernier adjustment of the output frequency from the front panel. Because the oscillator is contained in a sealed unit and must be returned to the factory for repair, a schematic diagram of the circuit is not included in this manual. The output signal is available at the rear-panel connector J17 for coaxial cable connection to the STD FREQ IN connector or to an external load. The output voltage is 1 volt into a 50 ohm load.

3-27. INPUT CIRCUITRY

3-28. The Frequency Standard Input circuits are located on assembly A4, the Phase Shifter Module. They are depicted schematically on Drawing No. 207-1-103. The input signal to the pulse shaper is derived from a local frequency standard. It can be a signal from an external "in house" standard or, in the case of the Model 207-4 and 207-5, it can be the internal frequency standard output signal. The signal can be any integral multiple of 100 kHz from 100 kHz to 1 MHz in the voltage range from 0.2 to 5 volts, rms (sine wave). Furthermore, the signal can be a square wave, a sine wave or a complex pulse waveform. The signal is connected to the input circuits through the rear-panel 100 KHz - 1 MHZ STD FREQ IN connector (J11). The input impedance is 1 kilohm.

3-29. Transistor Q3 is a constant current source for transistors Q1 and Q2. During positive excursions of the input signal, the emitter of Q1 (and diode CR1) follows the signal, back biasing diode CR2 and cutting off transistor Q2. During negative input-signal excursions, the emitter of Q2 starts to follow the signal but when diode CR2 begins to conduct, the constant current is switched to Q2 and Q1 is cut off. The switching action is rapid and the resulting Q2 collector waveform is a square wave at the frequency of the input signal. Additional Squaring occurs in over-driven transistor Q4.

3-30. Transistors Q6, Q7 and Q8 are the active elements of a one-shot multivibrator. A positive going trigger signal at the base of Q5, drives the collector negative. This negative-going signal is coupled to the base of transistor Q8 through emitter follower Q7. The negative excursion is sufficient to cut off Q8, allowing the collector voltage to approach +13 volts (+ V1). This voltage is coupled to the base of Q6 through resistive divider R14-R12, turning the transistor on and clamping the base of Q7. This action effectively blocks subsequent trigger signals through Q5. After the initial switching that turns off transistor Q8, capacitor C9 begins to change through resistors R15 and R16. The time constant of this circuit is such that Q8 begins to conduct in slightly less than 10 usec. As Q8 begins to conduct, the falling collector voltage is coupled to the base of Q6, reinforcing the switching action through emitter follower Q7. With transistor Q8 conducting, and transistor Q6 cutoff, negative-going trigger signals can be coupled to Q7 through Q5. Upon the arrival of the next trigger pulse, (10 usec after the first) the cycle is repeated. The net result is a negative going pulse at the collector of Q8 every 10 usec. This corresponds to a frequency of 100 kHz.

3-31. During the negative excursions of the 100 kHz pulse train, transistor Q10 is turned on, exciting tuned circuit L1-C11. This circuit is tuned to 900 kHz and the sine wave output is coupled to pin 10 of P3 through transformer T1. From P3 the signal is connected to pin 14 of P2 on assembly A5 and as will be seen later, performs a vital signal function in the Frequency Divider. At this point it is important to recognize that the 900 kHz signal is derived from, and therefore is coherent with, the local frequency standard. The 100 kHz pulse signal also drives transistor Q9 where it is inverted and connected to pin 12 of P3. From P3, the positive 100 kHz pulses are connected to pin 18 of P4 on assembly A7, the Readout Module. Again, it is vital to recognize that this signal is coherent with the local frequency standard and also the 900 kHz sine wave.

3-32. In pnp transistor Q11, the negative 100 kHz pulses excite the collector load tuned to 1 MHz. The resulting 1 MHz sine wave output is coupled through transformer T2 to amplifier Q12. The output of Q12 overdrives transistor Q13 resulting in a square wave

at the collector. This 1 MHz square wave is coupled directly to one input of the phase shifter circuits and is referred to as the 1 MHz signal. The 1 MHz square wave is also coupled to the base of Q27. During the negative-going transition of the square wave, the transistor is cutoff. However, the collector voltage does not rise immediately. Instead, capacitor C20 is charged through R32 and the base of Q14 (held into conduction by current through R31). Capacitor C20 charges to about 3 volts. During the positive-going transition of the 1 MHz square wave, transistor Q27 is turned on causing its collector voltage to fall rapidly. This action drives the base of Q14 negative due to the stored charge in C20. Q14 is cutoff resulting in a positive-going transition at its collector. As capacitor C20 discharges through R31 and the collector of Q27, the voltage at the base of Q14 begins to rise. In about 0.25 useconds (1/4 cycle or 90 electrical degrees at 1 MHz) the base of Q14 is sufficiently positive to turn on the transistor. This results in a negative-going transition at its collector.

3-33. In the stylized waveforms of Figure 3-5, note that a positive-going transition of the 1 MHz square wave results in a positive-going transition at the collector of Q14, followed 1/4 cycle (90°) later by a negative transition. Both of these signals are used to trigger integrated circuits components which respond to negative-going transitions. Consequently, only the negative-going transitions are of importance in the ensuing circuit operation. For this reason, the output at the collector of Q14 is termed "1 MHz + 90°." (The negative-going transitions occurs 90° before the negative transition of the 1 MHz signal.)

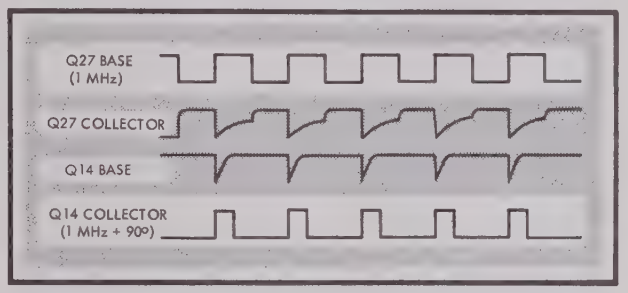


Figure 3-5. FREQUENCY-STANDARD DELAY-CIRCUIT WAVEFORMS

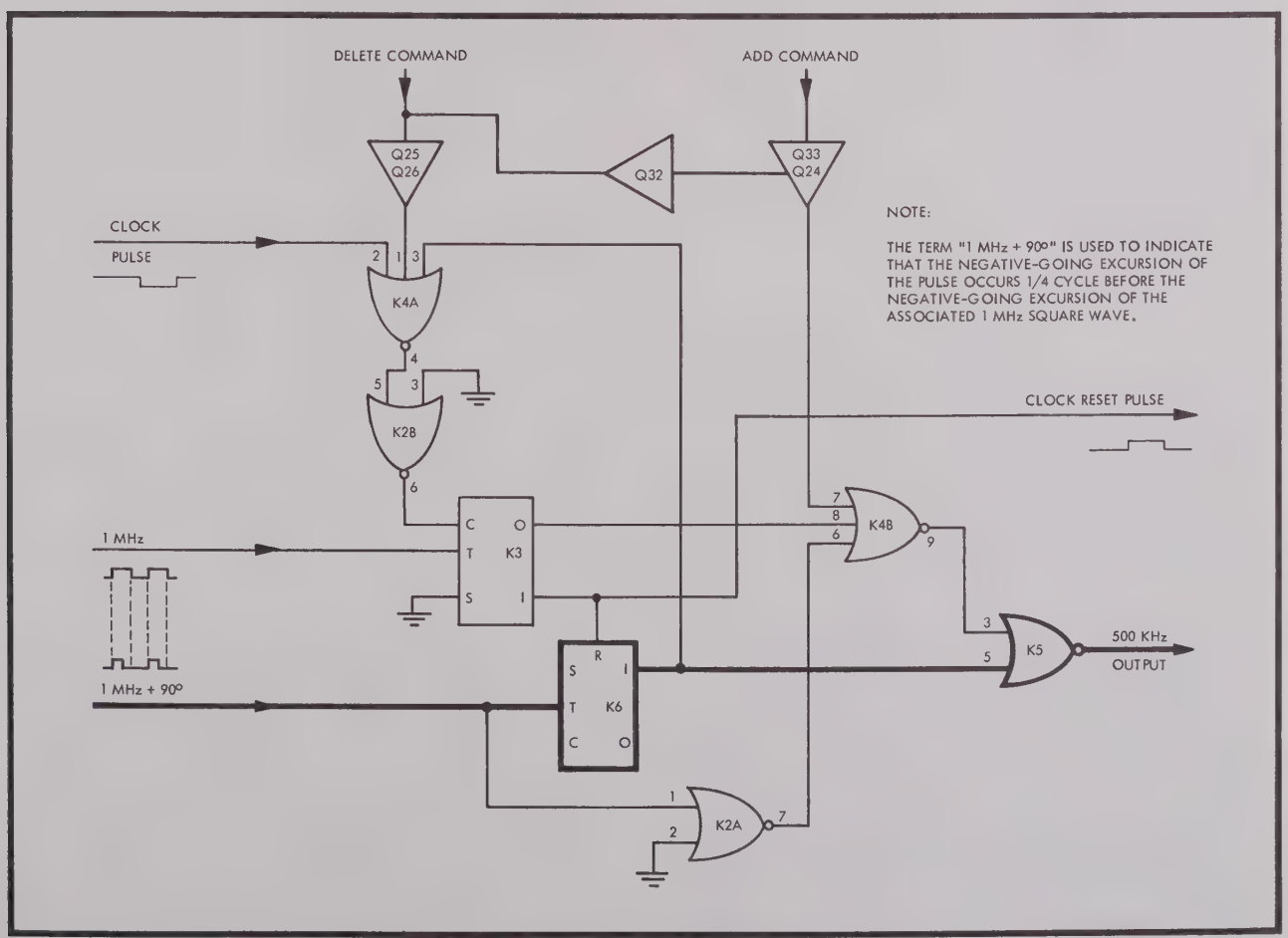


Figure 3-6. SIMPLIFIED PHASE-SHIFTER BLOCK DIAGRAM

3-34. THE PHASE SHIFTER

3-35. INTRODUCTION

3-36. The circuits depicted within the shaded area of Figure 3-4 are collectively called the Electronic Servo. The functions of the servo are (1) to generate a 1.1 kHz signal from the 1 MHz local frequency standard, (2) to compare the signal to a broadcast frequency standard and (3) to maintain a fixed phase relationship between the generated signal and the broadcast signal. There are three principle elements in the servo: the Phase Shifter, the Frequency Divider and the Phase Detector. The Phase Shifter circuits are located on Assembly A6, the Phase Shifter Module. They are depicted schematically on Drawing No. 207-1-103.

3-37. The function of the phase shifter is to derive a 500 kHz signal from the local frequency standard and shift its phase in response to dc feedback from the Phase Detector Module. The principle circuits of the phase shifter are shown in the simplified block diagram of Figure 3-6. In this diagram, the delete command and add command signals are dc voltages developed in the phase detector. When the phase detector senses a need to advance the phase of the 500 kHz signal, a positive voltage is present at the add command terminal. And, similarily, when the phase must be retarded a positive voltage is present at the delete command terminal. As will be shown later in the explanation of the phase detector, a command voltage can be present at only one terminal at a time. The clock pulse is generated in the variable-rate clock circuits to be discussed later. The repetition rate of this pulse is variable and is dependent upon (1) the selected tracking rate and (2) the magnitude of the phase error. For purposes of this explanation, it is sufficient to understand that a low-state clock pulse is present at input 2 of K4 approximately every one or two seconds.

3-38. DELETE COMMAND CIRCUIT RESPONSES

3-39. During normal operation of the phase shifter and in the absence of a clock pulse, the output of IC flip-flop K6 is alternately switched from one state to the other by the negative transitions of the 1 MHz + 90° signal at the trigger (T) terminal. This results in a 500 kHz square wave at input 5 of the 2-Input Gate, K5. Input 3 is held in a low state by K4 in the absence of a clock pulse and the transitions at input 5 appear inverted at the output.

3-40. Circuit responses as the result of a delete command are illustrated by stylized waveforms in Figure 3-7. The specific circuit responses leading directly to the deletion of one transition in the 500 kHz output signal are emphasized by the unshaded arrow no. 1. Arrow no. 2 emphasizes circuit responses leading to the resumption of normal operation. The delete command signal is inverted in the amplifier Q25/Q26, establishing a low input state at input 1 of K4A. Input 2 is also switched to a low state upon the occurrence of the negative clock pulse. Then, the next negative-going transition of K6 output 1 switches K4A input 3 to its low state. With all three inputs of K4A in their low states, the output assumes its high state. This signal is inverted in K2B, resulting in a low state at input C of K3. With input C low, the 1 MHz triggering signal switches output 1 to its high state. This signal, connected to the reset terminal of K6, holds output 1 in its low state during one transition of the 1 MHz + 90° triggering signal. The output of K3 is also connected to the variable-rate clock and in effect resets the output to its high state. This action returns input 2 of K4A to a high state and through K4A and K2B, returns K3 input C to its high state. With input C of K3 in a high state, the next triggering signal returns output 1 to its low state, removing the reset-input restraint of K6. Ensuing 1 MHz + 90° triggering signals switch K6 in the normal manner. At the bottom of Figure 3-7, the resulting 500 kHz output signal is drawn immediately above a normal 500 kHz signal for comparison. Note that the two waveforms are in phase at the outset, but are 180° out of phase after the deletion of one transition.

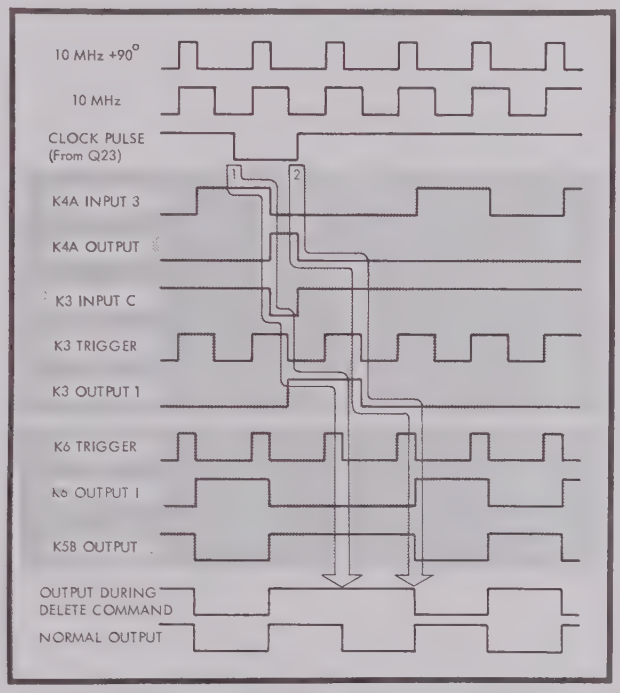


Figure 3-7. PHASE-SHIFTER WAVEFORMS DURING DELETE COMMAND

3-41. ADD COMMAND CIRCUIT RESPONSES

3-42. When the servo phase detector senses a need to advance the phase of the 500 kHz signal, a positive voltage is fedback to the input of amplifier Q33/Q24. This command signal is coupled through Q32 to the input of amplifier Q25/Q26. The immediate response to the command signal is a low state at K4A input 1 and K4B input 7. Ensuing circuit responses are depicted by stylized waveform in Figure 3-8. As during the delete command sequence, the clock pulse and K6 output 1 signals establish a low state at K3 input C through K4A and K2B. K3 is triggered by the 1 MHz square wave switching output 0 to its low state. K3 output 1 is also switched and prevents K6 output switching as before. The low state of K3 output 0 is coupled to K4B input 8.

The 1 MHz + 90° pulse train is inverted in K2A and coupled to input 6 of K4B. When the 1 MHz + 90° pulse switches input 6 to its low state, the output of K4B is switched to its high state. This positive signal is coupled to input 3 of K5 resulting in a negative pulse at the output. The duration of this negative pulse is about 0.25 useconds (one quarter of a 1 MHz cycle). As in the delete command sequence, K3 output 1 resets the variable-rate clock and through K4A, K2B and K3, restores normal operation. The resulting output waveform is compared to a normal signal at the bottom of Figure 3-8. Note that the signals are 180° out of phase following the add command sequence. At first glance this may seem identical to the results of the delete command sequence. However, in this case there are four negative-going transitions of the 500 kHz signal as compared to only three during a corresponding time span of the delete-command signal. This is important to remember because these signals accomplish frequency division by triggering flip-flop counters in succeeding circuits.

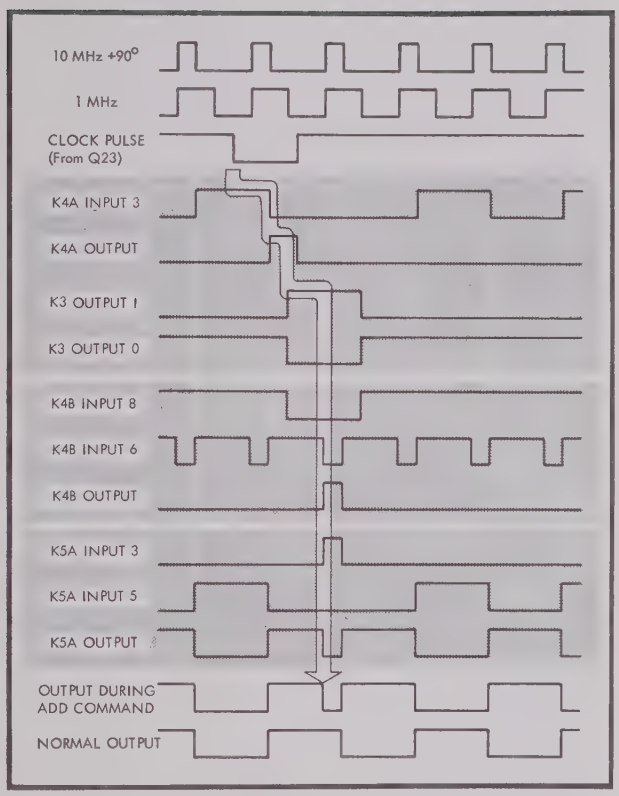


Figure 3-8. PHASE-SHIFTER WAVEFORMS DURING ADD COMMAND

3-43. MANUAL PHASE SHIFTING

3-44. Referring to Drawing No. 207-1-103, the add and delete commands are connected to the bases of Q33 and Q25, respectively, through pins 22 and 21 of connector P3. The circuits can also be actuated manually with the front-panel SERVO PHASE switch. When this switch is placed in the ADVANCE position, an add command voltage is introduced through pin 19 of P3. Simultaneously, K4A input 2 (clock pulse input) is switched to its low state by grounding pin 20. When switch S4 is placed in

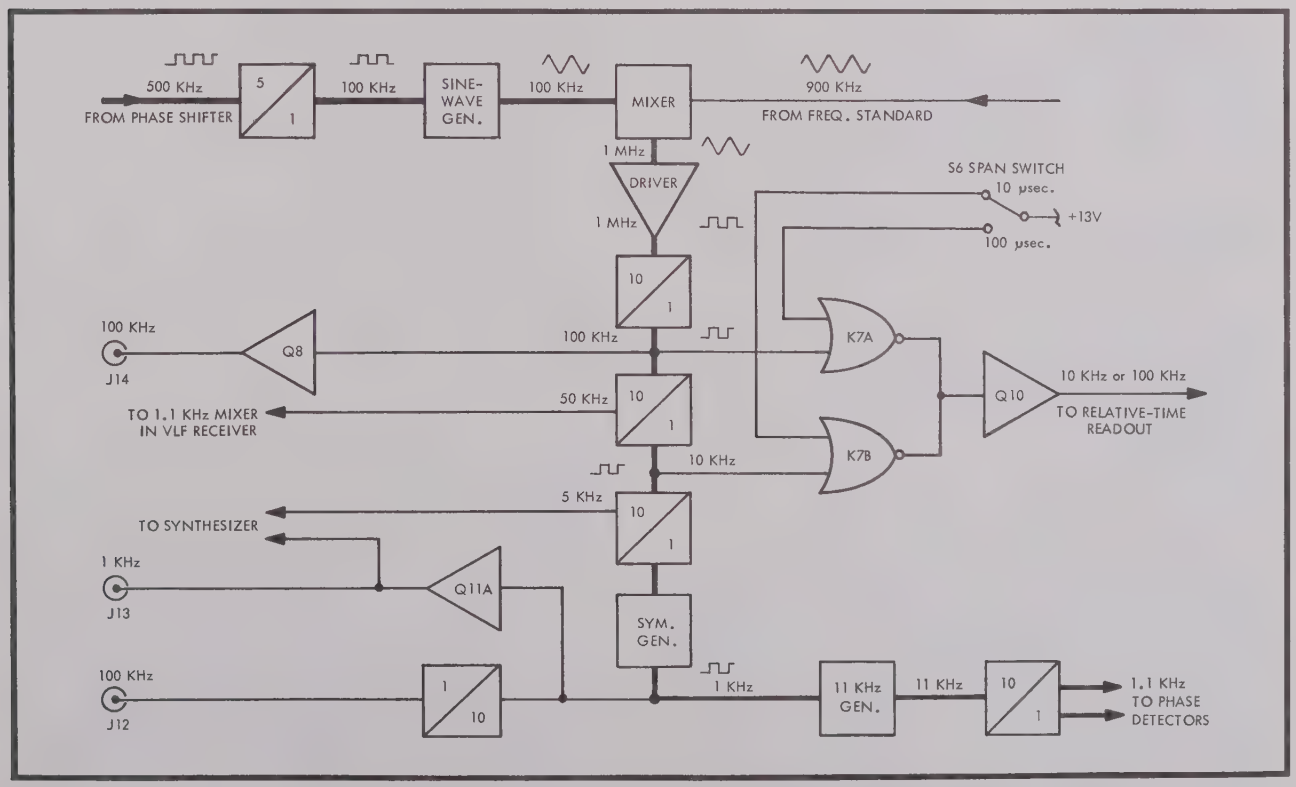


Figure 3-9. SIMPLIFIED FREQUENCY-DIVIDER BLOCK DIAGRAM

the RETARD position, the delete command is connected through pin 17 of P3. And, as before, K4A input 2 is switched to its low state by grounding pin 18. Pin 20 also serves to connect a no-signal lockout function to the phase shifter. When the front-panel NO-SIGNAL lamp is illuminated, a positive voltage appears at pin 20 to hold K4A input 2 in its high state. This action "locks out" clock pulses and prevents further phase shifting until the NO-SIGNAL lamp is extinguished. However, grounding either pin 20 or pin 19 by actuating the SERVO PHASE switch will override the lock-out signal permitting manual phase shifting.

3-45. THE FREQUENCY DIVIDER

3-46. CIRCUIT FUNCTIONS

3-47. The frequency divider elements of the electronic servo are located on Assembly A5, the Frequency Divider Module. They are depicted schematically on Drawing No. 207-1-102. The circuit functions are illustrated in the simplified block diagram of Figure 3-9. Here, the 500 kHz square wave from the phase shifter is first divided by five and then converted to a sine wave. The 1 usecond phase-shift increments of the phase shifter appear at this point as 36° increments of the 100 kHz sine wave. (The period for one cycle is 10 useconds. 1 usecond is one tenth of a period or 36 electrical degrees.) In the mixer, the 100 kHz signal is added to a 900 kHz sine wave (derived from the local frequency standard; see paragraph 3-31) to produce a 1 MHz output. The 36° phase shift increments also appear in the output, but at 1 MHz, 36° corresponds to 0.1 usecond.

3-48. The mixer output signal is converted to a square wave in the driver amplifier and is used to trigger the first of three ten-to-one frequency dividers. The frequency dividers divide the 1 MHz square wave down to 1 kHz. Because the dividers only respond to negative-going signal excursions, the 0.1 usecond phase-shift increments appear as 0.1 usecond time displacements in the 1 kHz output. The symmetry generator processes the 1 kHz signal to make the negative half-cycle time span equal to the positive half cycle. The resulting 1 kHz square wave excites the 11 kHz generator, the output of which is divided by ten to produce the desired 1.1 kHz outputs to the phase detectors. As can be seen in the simplified block diagram, signals at various points in the frequency division process are selected to perform secondary signal functions. It is important to recognize that all of these signals are coherant with the 1.1 kHz outputs.

3-49. FIVE-TO-ONE FREQUENCY DIVIDER

3-50. The five-to-one frequency divider of Figure 3-9 consists of one transistor, Q1, and three IC flip-flops, K1, K2 and K3. Circuit responses are depicted by stylized waveforms in Figure 3-10. Switching sequences are emphasized by six unshaded arrows. For purposes of explanation, we assume initial circuit conditions in which output 0 of K1 is in its low state; output 1 of K2 is in its high state; and output 1 of K3 is in its low state. Referring to Figure 3-10, the positive-going excursion of the 500 kHz signal is inverted through Q1 and appears

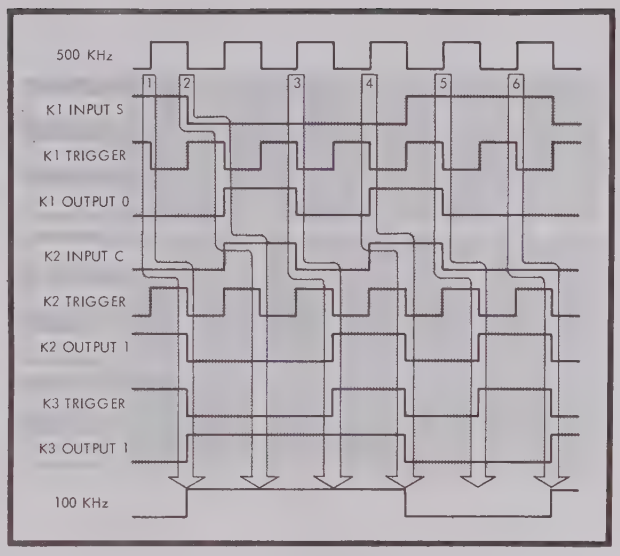


Figure 3-10. FIVE-TO-ONE FREQUENCY DIVIDER WAVEFORMS

as a triggering signal to K1. K1 does not switch states, however, because input S is high. The next 500 kHz transition triggers K2, switching output 1 to its low state. This negative-going transition triggers K3, switching output 1 to its high state. This transition marks the beginning of the output signal cycle.

3-51. The switching of K3 establishes a low state at input S of K1, setting the stage for the next switching sequence (arrow 2). With input S of K1 in its low state, the next positive-going excursion of the 500 kHz input is inverted by Q1 to trigger K1. Output 0 of K1 switches input C of K2 to its high state. When the 500 kHz input signal goes negative, K2 is triggered. But because input C is high, output 1 remains in its low state and K3 is unaffected.

3-52. During the next positive-going transition of the 500 kHz signal (arrow 3), K1 is triggered, switching its output 0 and K2 input C to the low state. Then, K2 is triggered by the 500 kHz signal, switching output 1 to the high state. Because this is a positive-going transition, K3 is unaffected.

3-53. The next positive-going transition of the 500 kHz input (arrow 4) triggers K1, switching output 0 to the high state. With K2 input C high, the following 500 kHz negative transition triggers K2 output 1 to its low state. This negative-going transition, in turn, triggers K3, switching output 1 to its low state.

3-54. The fifth positive-going transition of the 500 kHz input marks the concluding switching sequence for the cycle. This transition triggers K1, switching output 0 and K2 input C to the low state. K2 is triggered by the following negative excursion returning output 1 and the K3 trigger input to the high state. Arrow 6 in Figure 3-10 traces the switching sequence that begins a new cycle as did arrow 1.

3-55. 1 MHZ MIXER

3-56. The 100 kHz output from the five-to-one divider is converted to a sine wave in the tuned collector load of Q2, a pnp transistor. The low state of K3 output 1 turns on Q1, gating current to the collector load for approximately 40% of one cycle. These current pulses excite the tuned circuit, C1/T1, resulting in a sine-wave output to the base of Q3. Q3 amplifies the signal for coupling to the emitter of Q4. The base of Q4 is connected through pin 14 of P2 to the 900 kHz source on the Phase Shifter Module.

3-57. You can gain an intuitive understanding of the mixer circuit operation by reviewing the principles of heterodyning. When two sine waves, f_1 and f_2 are mixed in a nonlinear device, there are four output signals: the original two signals and the sum and difference of the two. In this case, we are concerned with the sum of the two or, mathematically:

$$f_1 + f_2 = f_3$$

It is also true that the phase angle of the two signals are added in the process and the situation is more completely described as follows:

$$f_1 \angle a^\circ + f_2 \angle b^\circ = f_3 \angle c^\circ$$

In the above equation the notation $f_1 \angle a^\circ$ is read, "frequency f_1 at phase angle 'a' degrees." Phase angle c is the sum of phase angles a and b. Because the 900 kHz signal is coherent with the 500 kHz input to the phase shifter, it is arbritarily assigned reference phase angle 0°. Before the 500 kHz (and as a result, the 100 kHz) signal is phase shifted, the mixer output signal is described as follows:

$$100\ \text{kHz} \angle 0^\circ + 900\ \text{kHz} \angle 0^\circ = 1\ \text{MHz} \angle 0^\circ$$

When the phase shifter advances or retards the phase one increment (36°) the expression becomes:

$$100\ \text{kHz} \angle \pm 36^\circ + 900\ \text{kHz} \angle 0^\circ = 1\ \text{MHz} \angle \pm 36^\circ$$

However, at 1 MHz, a phase shift of 36° is equivalent to a time displacement of 0.1 usecond. In summary, the 1.0 usecond time displacements of the 100 kHz input signal result in 0.1 usecond displacements of signals in succeeding circuits.

3-58. The 1 MHz output is coupled to amplifier Q5 through transformer T2. T2 and L1, of course, are tuned to 1 MHz. The large output excursions at the collector of Q5 are coupled through C7 to the base of Q6. This transistor is company with diode CR5 operates as a signal clipper, producing 1 MHz square waves at the collector output.

3-59. TEN-TO-ONE FREQUENCY DIVIDERS

3-60. The first of the three ten-to-one frequency dividers divides the 1 MHz square wave to 100 kHz. The divider consists of transistors Q7 and flip-flops K4, K5, K6 and K8. Flip flops K4, K5 and K6 respond to the 1 MHz signal identical to the five-to-one frequency divider discribed in paragraph 3-49. The output at terminal 1 of K6 is one fifth of the input signal frequency or 200 kHz. Flip flop K8 is triggered by this signal resulting in a 100 kHz signal at output 1.

3-61. The 100 kHz square wave is also connected to the second ten-to-one divider consisting of K9, K10, K11 and K12. Here the signal is first divided by two in flip flop K9. The 50 kHz complementary square waves at output 1 and 0 drive a five-to-one divider consisting of K10, K11 and K12. The circuit responses of the devices are identical to the responses of K1, K2 and K3 of paragraph 3-49.

3-62. The third ten-to-one frequency divider divides the 10 kHz output of K12 to 1 kHz. IC flip flops K13, K14, K15 and K16 respond to the input signal in the same way as the second divider. That is, K16 divides the signal by two and K13, K14 and K15 divide the 5 kHz by five.

3-63. As shown by the bottom waveform of Figure 3-10, the output waveform from a five-to-one frequency divider is unsymmetrical. That is, the signal remains in the high state longer than it remains in the low state. The output of the third ten-to-one divider is similarily unbalanced. To achieve signal symmetry necessary for ensuing circuit functions, the 1 kHz signal is processed in the symmetry generator, K27.

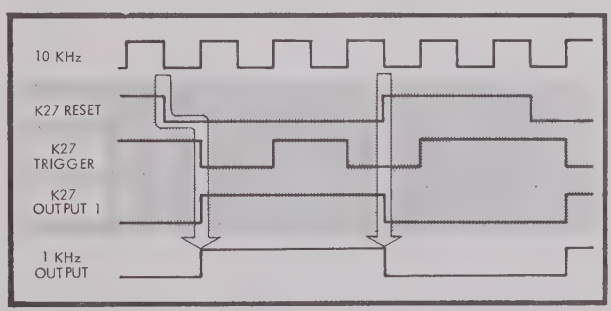


Figure 3-11. 1 KHz SYMMETRY-GENERATOR WAVEFORMS

Signal responses are depicted in Figure 3-11. In this illustration the 1 kHz output is related to the 10 kHz input of the ten-to-one divider. The K27 reset waveform is the normal frequency divider output. Initially, K27 output 1 is held in its low state by the high output of K15 (K27 reset waveform). This restraint is removed when K15 is triggered to its low state. K27 is then triggered to its high state by the negative transition of K13 output 1. The second transition of K27 occurs when K15 output 0 returns to its high state, resetting the flip flop. As shown in Figure 3-11, the resulting waveform is symmetrical. The complementary outputs are connected to a fourth ten-to-one divider (K23, K24, K25 and K26) to provide a coherent 100 kHz signal.

3-64. 11 KHZ GENERATOR

3-65. The 1 kHz square wave at K27 output 1 switches current through Q13 to the tuned circuit L2/C9. The

current pulses excite the circuit to resonate at 11 kHz and the sine wave output is coupled to transformer T3. Transistor Q9 amplifies the 11 kHz sine wave to drive the clipping circuit consisting of CR2 and the base/emitter junction of Q12. The output signal at the collector of Q12 is an 11 kHz square wave.

3-66. 1.1 KHZ OUTPUT CIRCUIT

3-67. The 11 kHz square wave output from Q12 is connected to a phase inverter consisting of 2-input gates K17A and K17B. Positive-going excursions at the output of K17A are inverted through K17B to result in complementary inputs to K18 and K19. These flip flops are the input elements of a ten-to-one frequency divider. Flip flops K18, K19 and K20 function as a five-to-one divider and their performance is identical to K1, K2 and K3 of paragraph 3-49. K21 functions as a two-to-one divider resulting in complementary 1.1 kHz square wave at the S and C inputs to K22.

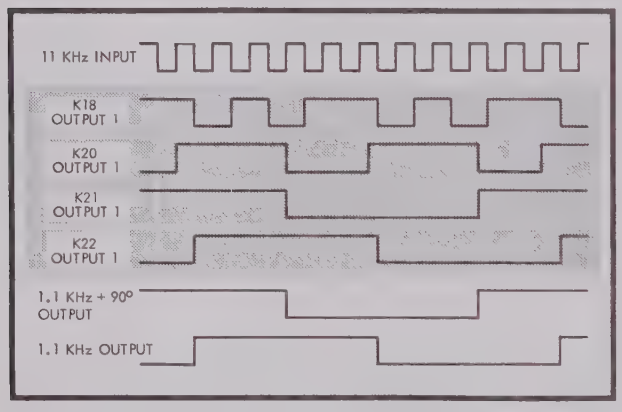


Figure 3-12. 1.1 KHz DIVIDE-BY-TEN WAVEFORMS

3-68. K22 serves to provide two 1.1 kHz square wave outputs; one occuring 1/4 cycle in advance of the other. The circuit response are depicted by waveforms in Figure 3-12. In this illustration, the key five-to-one divider waveforms are shown as they appear in Figure 3-10. K18 output 1 corresponds to an inverted K1 output 0, and K20 output 1 corresponds to K3 output 1. K21 functions as a tow-to-one frequency divider, triggered by the output from the five-to-one divider. Output 1 of K21 is connected to pin 21 or P2 and is termed the 1.1 kHz + 90° output. The outputs from K21 are also connected to inputs S and C of K22, establishing the output states following triggering. But as can be seen in Figure 3-12, K22 is triggered by K18 output 1 and the output transistors occur 1/4 cycle after the 1.1 kHz + 90° signal transitions. For this reason, the signal at pin 22 of P2 is termed the 1.1 kHz output.

3-69. SECONDARY SIGNAL CIRCUITS

3-70. In addition to the 1.1 kHz outputs to the phase detector, the frequency divider also provides coherent signals for circuit functions elsewhere in the instrument. To provide two relative-time scales on the chart recorder, either the 100 kHz or the 10 kHz signal can be selected by a rear-panel control. When switch S6, the SPAN switch, is set at 100 useconds, input 2 of K7A is set at its high state. This action switches the output to its low state, blocking the transmission of the 100 kHz signal at input 1. As a consequence, the 10 kHz signal is gated through K7B to the base of Q10. In a similar way, placing switch S6 in its 10 usecond position, gates the 100 kHz signal to the base of Q10. The output from Q10 is connected through pin 3 of P2 to the relative-time readout circuits.

3-71. Coherent signals are also necessary for the correct operation of the vlf receiver and associated frequency synthesizer. In instruments below serial number 225, the 5 kHz and 100 Hz square waves are connected to the receiver and synthesizer through pins 4 and 7, respectively. In instruments above serial number 224, the 1 kHz and 100 Hz are connected through pins 6 and 7, respectively. Additionally, the 50 kHz signal from the second ten-to-one divider is connected to the receiver 1.1 kHz mixer through pin 1.

3-72. Three coherent-signal outputs are provided on the rear panel of the instrument. These signal connections are not vital to normal instrument functions but are provided for the operation of associated auxiliary equipment. The 100 kHz square wave is connected through Q8 to connector J14, the 1 kHz square wave is connected through Q11 and pin 6 to connector J13, and the 100 Hz is connected through pin 16 to connector J12.

3-73. THE SERVO PHASE DETECTOR

3-74. INTRODUCTION

3-75. The function of the servo phase detector is to develop a dc feedback voltage proportional to the magnitude of phase difference between the received vlf-standard signal and the frequency-divider signal. The circuit is located on the Phase Detector Module, A4. The circuit schematic diagram is included on Drawing Number 207-1-101. Note that this drawing includes two phase detectors: the servo phase detector and the signal phase detector. We are concerned here only with the servo phase detector.

3-76. THE PHASE DETECTOR

3-77. The 1.1 kHz signals to be compared are introduced to the phase detector through pins 21 and 14 of P1. The signal at pin 21 is the output signal from the receiver if amplifier. The signal at pin 14 is the 1.1 kHz + 90° square wave from the frequency divider. The signals are compared in the base/emitter circuits of the differential-amplifier pair Q1A and Q1B. Circuit responses are illustrated in Figure 3-13.

3-78. The 1.1 kHz + 90° signal from the Frequency Divider Module is amplified in Q15 to drive the grounded-base amplifier Q16. Q16, in turn, drives transistor Q17 in the emitter circuits of Q1A and Q1B. During the time Q17 is turned on, it functions as a constant current source. That is, it meters a fixed amount of current to Q1A and Q1B through resistors R6 and R7. During the time it is turned off, Q1A and Q1B do not have an emitter current source and are therefore also turned off. Referring to Figure 3-13, the 1.1 kHz signal from

the frequency divider is inverted in Q15 and appears 180° out of phase at the emitter of Q16 because it is a grounded base amplifier, there is no inversion in Q16 and the signal appears at the base of Q17 180° out of phase with respect to the 1.1 kHz frequency-divider signal.

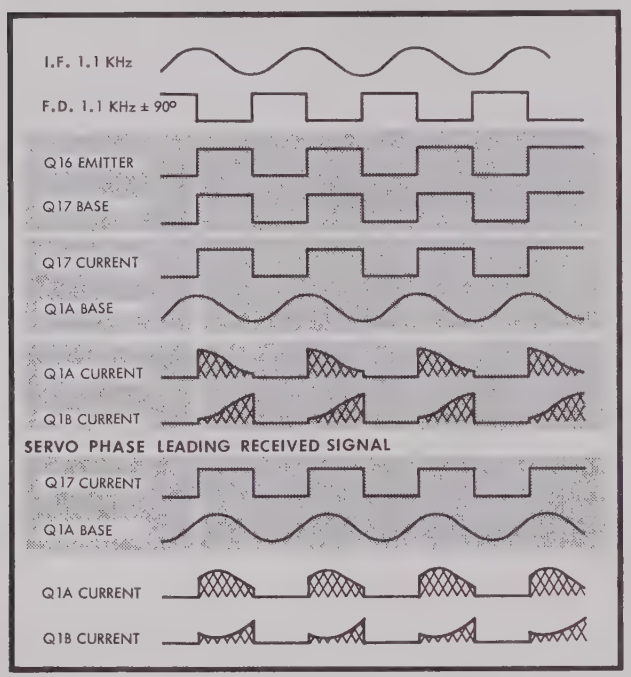


Figure 3-13. SERVO PHASE-DETECTOR WAVEFORMS

3-79. Transistors Q1A and Q1B function as a gated linear differential amplifier. The receiver output signal is coupled to the base of Q1A through capacitor C1; and to the emitter of Q1B through common-emitter coupling. The dynamic range of the amplifier is sufficient to linearly amplify the normal range of if-amplifier output signals. The signal depicted in Figure 3-13 is an approximation of the if-amplifier output for an antenna input voltage of 0.3 microvolts. In practice, the received signal amplitude is usually greater than 1 microvolt and the if-amplifier output signal is a 1.1 volt, peak-to-peak, square wave. During the time Q17 is conducting, the signal is amplified by Q1A and Q1B, however, the resulting collector currents are 180° out of phase. For zero phase difference as depicted at the top of Figure 3-13, the "area under the curve" of the resulting collector currents are equal. As will be shown later, this condition would result in zero feedback to the servo phase shifter.

3-80. Consider next, the circuit operation when the received signal is retarded in phase with respect to the frequency-divider signals. At the bottom of Figure 3-13, this condition is portrayed by shifting the Q1A base waveform to the right. In this case, the area under the curve of the Q1A collector-current waveform is larger than the area under the Q1B collector-current waveform. In a similar manner, it can be shown that the area under the Q1B collector-current waveform would be the larger of the two if the received-signal phase was advanced. In summary, phase differences between the received signal and the frequency-divider signal result in unequal current pulses through Q1A and Q1B. When the frequency-divider signal leads the received signal (and therefore must be retarded to restore zero phase difference) the total current through Q1A is greater than the current through Q1B.

3-81. THE OPERATIONAL INTEGRATOR

3-82. The current pulses through Q1A and Q1B are converted to dc voltages in two operational integrators. The operational integrator associated with Q1A consists of transistors Q2A and Q3, connected as a high-gain dc amplifier, and integrating capacitors A28C5 through A28C8. Similarily, transistors Q2B and Q4 and capacitors A28C1 through A28C4 are associated with Q1B. To simplify the explanation of these circuits, we consider first the operational integrator associated with Q1A. It is depicted by simplified schematic in Figure 3-14.

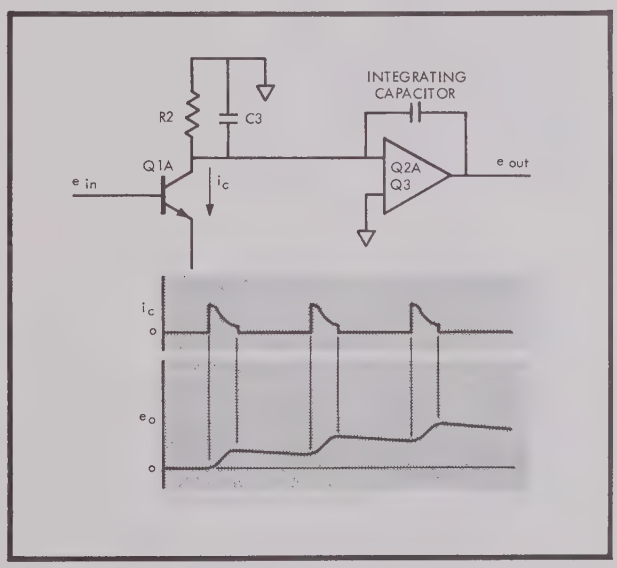


Figure 3-14. SIMPLIFIED OPERATIONAL INTEGRATOR

3-83. During the time Q1A is conducting, the collector current (i_C) begins to charge capacitor C3, causing the collector voltage to tend negative. This negative-going voltage results in a positive-going excursion at the output of amplifier Q2A/Q3. With the amplifier input tending negative and the output going positive, the integating capacitor begins to charge. The circuit for the charging current is through the collector of Q1A. The net result is a rising voltage at the output during the interval that Q1A is conducting. The magnitude of the output voltage is proportional to the area under the curve of the collector-current waveform. When Q1A is cutoff, capacitor C3 begins to discharge through R2 tending to cause the input of the amplifier to go positive. This, in turn, results in a negative-going output voltage. However, the discharge rate is much slower than the charge rate. The resulting output waveform is exaggerated for clarity in Figure 3-14.

3-84. During signal conditions illustrated at the top of Figure 3-13, the equal current pulses would result in equal dc output voltages at the emitters of Q3 and Q4. However, such equality rarely exists in practice. Generally, one current pulse will always be greater than the other. In the emitter circuits of Q2A and Q2B, such differences are accentuated. When the current pulse through Q1A is greater than the pulse through Q1B, capacitor C3 will be charged to a more negative value than capacitor C4. This negative voltage is coupled through the emitter of Q2A to the emitter of Q2B, tending to increase its forward bias, in opposition to its base voltage. The overall effect of this cross coupling is a tendency to integrate the difference between collector currents in Q1A and Q1B, rather than the absolute values of current.

3-85. The magnitude of the operational-integrator output voltage is a function of two parameters: the value of the integrating capacitor and the area under the curve of the collector-current waveform. When the integrating capacitor is small, the output voltage will rise rapidly, achieving maximum value in a shorter time than if the capacitor were larger. The value of the capacitor can be selected with the front-panel TRACKING RATE switch. This permits selecting a value (and, as a result, a speed of response) appropriate to the expected rate of change of signal phase. Coincidentally, the TRACKING RATE switch also provides for an appropriate read-out interval in the accumulative-error circuits.

3-86. THE LEVEL DETECTOR

3-87. When the frequency divider output signal lags the received signal, the output voltage at the emitter of Q3 is more positive than the output at the voltage at the emitter of Q4. This voltage difference at the bases of Q6 and Q8, turns on transistor Q8 while turning off Q6. This action permits current flow through Q8 to pin 19 of P1 and the Add-Command input of the Phase Shifter Module. Simultaneously, the voltage difference turns on transistor Q9 and turns off Q10. This prevents current flow through pin 18 of P1 and the Delete-Command circuit. Conversely, when the frequency divider output leads the received signal, the more negative voltage at the emitter of Q3 turns on Q6 and Q10, permitting current flow in the Delete-Command circuit.

3-88. During those intervals when the emitter of Q3 is more positive than the emitter of Q4, transistors Q5 and Q7 are turned on. Similarily, when the emitter of Q4 is more positive, transistors Q11 and Q14 are turned on. Both sets of transistors share a common collector resistor, R31. Consequently, whenever there is a voltage difference between the outputs of the operational integrators (that is, whenever the comparator senses a phase difference) there will also be a voltage rise across R31. This voltage is coupled through diode CR1 to the No-Signal indicating circuits. The common-collector load R28 also develops a voltage proportional to the magnitude of the integrator output difference. This voltage, amplified by Q12, drives emitter-follower Q13. The load for Q13 is located in the variable-rate clock circuit of the Phase Shifter Module. As will be shown later, this voltage is used to vary the elapsed time of the readout cycle.

3-89. THE FREQUENCY SYNTHESIZER

3-90. INTRODUCTION

3-91. The function of the Frequency Synthesizer is to generate a signal 51.1 kHz higher than the received vlf frequency standard and phase locked to the signals developed in the Frequency Divider Module. The principle elements of the synthesizer are depicted in the block diagram of Figure 3-15. The voltage-controlled oscillator is a transistorized L/C oscillator with a varactor connected in parallel with the tuned circuit. The output frequency of the oscillator is ten times higher than the desired synthesizer output and is selected by the three front-panel FREQUENCY/KHZ controls. Fine adjustment of the output signal phasing is effected by a dc control voltage to the varactor. The output of the oscillator is connected to a series of binary counters which function as a variable-ratio frequency divider. The count-down ratio is determined by the settings of the FREQUENCY/KHZ controls and the output waveform is a 1 kHz pulse which triggers a miltivibrator initiating a pulse to the phase detector. The phase detector compares the multivibrator 1 kHz output with a signal from the frequency divider and develops a dc control voltage proportional to the phase difference. This control voltage is applied to the varactor and effects control of the oscillator output signal phasing. The oscillator output signal is divided by ten and connected to the 51.1 kHz mixer in the vlf receiver.

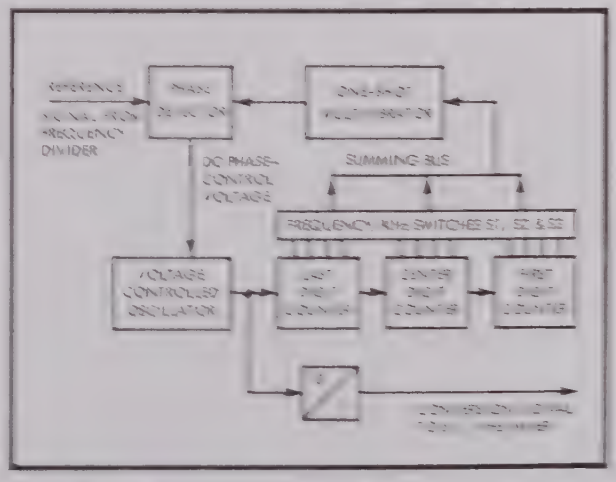


Figure 3-15. SIMPLIFIED FREQUENCY-SYNTHESIZER BLOCK DIAGRAM

3-92. The frequency synthesizer consists of seven printed circuit board assemblies. Five of the assemblies include all of the components for the binary counters. They are assemblies A29, A30, A31, A32 and A33. One printed circuit board, assembly A34, includes all of the components for the one-shot multivibrator, the phase detector and the ten-to-one frequency divider. Assemblies A29 through A34 are depicted schematically on Drawing Number 207-1-104. The voltage-controlled oscillator, assembly A27, is shown schematically on Drawing Number 207-1-105.

3-93. THE VOLTAGE-CONTROLLED OSCILLATOR

3-94. The function of the voltage-controlled oscillator is to generate a square-wave at a frequency ten times higher than the sum of the received signal plus 51.1 kHz (f_r + 51.1 kHz). The oscillator circuit is shown in the simplified schematic of Figure 3-16. The oscillator tuned circuit is the collector load for transistor Q1. The tuned circuit inductor is the primary of transformer T, which, as shown in Drawing 207-1-108, can be any-one of five transformers, T1 through T5. The selection of one transformer or the other is effected with the first digit switch, S3. The tuned circuit capacitance C is the sum of three groups of parallel capacitors. One group is associated with the selected transformer. The second group is associated with switch S2 and the third group with S1.

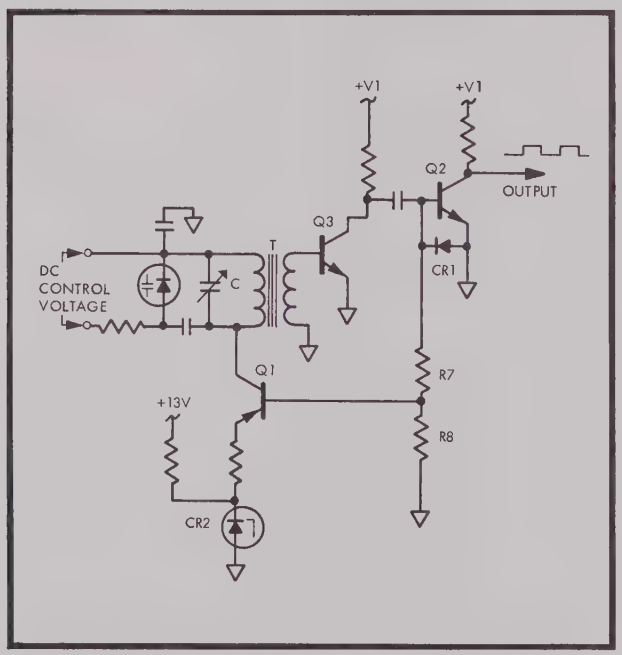


Figure 3-16. SIMPLIFIED VCO SCHEMATIC DIAGRAM

3-95. The oscillator feedback path is through the secondary of the transformer to the base of Q3, from the collector of Q3 to the resistive voltage divider R7/R8 and finally to the base of Q1. Zener diode CR2 and resistor R10 function as a stable, constant-voltage source for Q1, regulating the oscillator output voltage. The varactor is parallel with the tuned circuit is an encapsulated unit which includes a diode in series with the varactor. The temperature coefficient of the diode and the varactor are matched to provide constant capacitance-vs-voltage characteristics over the operating temperature range of the instrument.

3-96. The sine wave output of the oscillator is sufficiently large at the collector of Q3 to overdrive transistor Q2. This results in a square wave output at the collector. Diode CR1 clamps the signal at about -0.6 volts during the negative signal excursions.

3-97. THE PRESET COUNTER

3-98. The function of the preset counter is to divide the oscillator output frequency to 1 kHz. To this end it operates as a variable-ratio frequency divider. When the FREQUENCY/KHZ controls are set for the desired vco output frequency, the preset counter is simultaneously preset to count-down (divide the frequency) by an amount corresponding to the first three digits of the vco output frequency. For example, when the FREQUENCY/KHZ controls are adjusted to receive a 10.0 kHz signal, the vco output frequency is 611 kHz and the preset counter is set to count-down by 611. As can be seen in Drawing Number 207-1-124, the preset counter consists of three sets of binary counters; each set associated with one of the FREQUENCY/KHz controls (S1, S2, and S3).

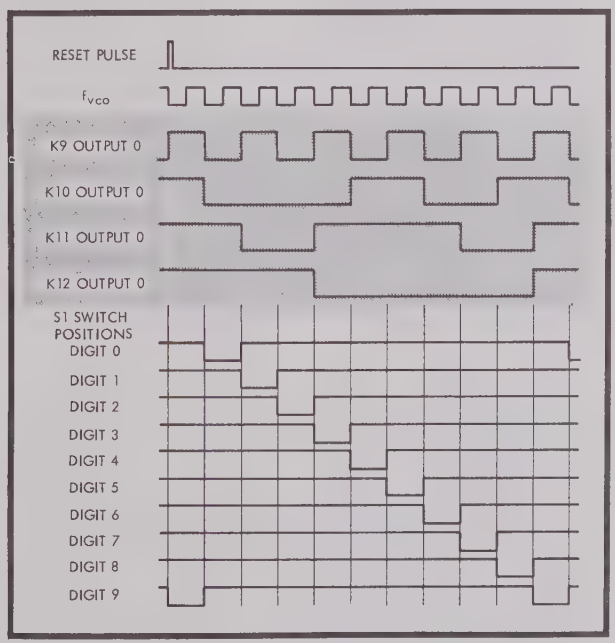


Figure 3-17. LAST-DIGIT COUNTER OUTPUT STATES TO THE SUMMING BUS

3-99. The operation of the last-digit counter is illustrated by stylized waveform in Figure 3-17. The active elements of the counter are IC flip flops K9, K10, K11 and K12. The reset terminals of these devices are all connected to a reset-pulse source. Initially, all of the flip flops are set to their zero-count state by the reset pulse. The voltage-controlled oscillator signal, f_{VCO}, is connected to the trigger input of K9. The four flip flops respond to the triggering signal in exactly the same manner as the ten-to-one frequency dividers of the Frequency Divider Module. The outputs from each of the flip flops are connected to a summing bus through S1, the front-panel switch used to select the last digit of the received signal. When digit 0 is selected, K9 output 0, K10 output 0, K11 output 1 and K12 output 1 are all connected to the summing bus through switches S1A, B,

C and D respectively. Referring to the waveform diagram of Figure 3-17, all of these outputs are simultaneously switched to their low states by the first f_{VCO} cycle following the reset pulse. Then, after counting ten cycles, the outputs are again simultaneously switched to their low state. In this case, the relative time of the pulse is in multiples of ten following the first output cycle. When switch S1 is turned to successively higher digits, the relative time position of the low-state output is moved to successively later times with respect to the preset pulse. The waveforms at the bottom of Figure 3-17, depict the summing-bus signal as though there were no other sources of current. However, each set of binary counters is connected to the summing bus and a low state will only occur when all three sets of counters switch to their low states simultaneously.

3-100. At the completion of ten counts, output 0 of K12 triggers K13, the first of four flip flops in the second-digit counter. Here, each cycle of ten counts is the last-digit counter results in one count in the middle-digit counter. The counting sequence in the middle-digit counter is the same as in the last-digit counter. And the flip flop outputs are connected to the summing bus in the same way through switch S2, the middle FREQUENCY/KHZ control. As a result, a low-state pulse can occur on the summing bus every time the counter counts the number of cycles of the last-digit counter corresponding to the second digit of the oscillator frequency. Each time the second-digit counter completes a cycle of ten counts, flip flop K16 triggers K17. Here again, each cycle of the middle-digit counter is tallied as one count in the first-digit counter.

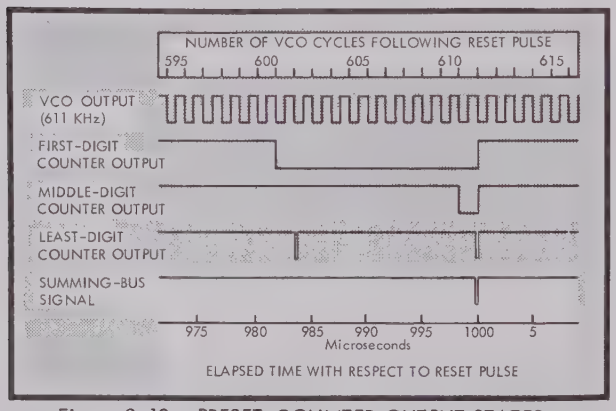


Figure 3-18. PRESET-COUNTER OUTPUT STATES IMMEDIATELY PRECEDING RESET PULSE R2 WHEN THE RECEIVER IS TUNED TO 10.0 KHz

3-101. The net result of the three counters periodically presenting low states to the summing bus is illustrated in Figure 3-18. Here, we continue the example of paragraph 3-97 and assume an oscillator output frequency of 611 kHz. At the beginning of the counting cycle, the last-digit counter presents a low state to the summing bus at the end of the second complete cycle following the reset pulse. And it continues to present a low state every ten cycles thereafter. This corresponds to the last digit of the desired oscillator frequency (1). After the last-digit counter completes one cycle of ten counts, the middle-digit counter presents a low state to the summing bus. And it continues to do so every ten counts thereafter. This corresponds to the middle digit of the oscillator frequency (1). Every time the middle-digit counter completes one cycle of ten counts, it in turn advances the first-digit counter one count. When the first-digit counter tallies six counts, it, too, presents a low state to the summing bus.

3-102. The events leading up to the terminal count of 611 are illustrated in Figure 3-18. When the first-digit counter responds to the 600th cycle (first-digit 6) it presents a low state to the summing bus. Following this, the middle-digit counter responds to the 610th cycle (second-digit 1) and it presents a low state to the summing bus. Finally, when the last-digit counter responds to the 611th pulse (last-digit 1) it too presents a low state to the summing bus. With all three counters in their low states, the summing bus voltage drops to its minimum value and triggers succeeding circuits. This triggering initiates the reset pulse, restoring the counters to their zero-count state.

3-103. In the illustration of Figure 3-17, notice that the summing-bus pulse for digit 9 occurs at the beginning of the counting cycle. In this special case, it is necessary to delete one count to the middle-digit counter for correct operation. (If the count were not deleted, the ninth count would register as number 19.) K23 and Q1 perform this circuit function. When switch S1 is placed in the 9th digit position, input 5 of K24B is ungrounded. In all other switch positions, this input is grounded, permitting the output of K12 to trigger K13. At the beginning of the counting cycle, K23 output 0 is reset to its high state. This voltage turns on Q1, setting the input to K24A at its low state, which, in turn, sets K24B input 5 to its high state. This action blocks triggering pulses from K12. When K12 output 1 goes negative at the completion of one counting cycle, K23 output 0 is triggered to its low state. Because input S is connected to +3.6 volts, further triggering has no effect on the output of K23 until it is reset at the beginning of the next counting cycle. When K23 output 0 goes negative, Q1 is turned off. Because of C1, the voltage rise at the collector is relatively slow. This has the effect of delaying the negative-going input to K24B. This delay is long enough to permit K12 to switch output states without triggering K13. Subsequent triggering pulses, of course, can trigger K13 with K24B input 5 in its low state.

3-104. Because the ninth digit also occurs at the beginning of the counting cycle in the middle-digit counter, the output of the first-digit counter must be offset. This is illustrated in Figure 3-19. Sub-sum A outputs appear on the summing bus when switch S2 is set for second digits in the range from 0 to 8, inclusive. Sub-sum B outputs are connected to the summing bus only when the second digit is 9.

3-105. PHASE DETECTOR (ABOVE S/N 225)

3-106. The function of the phase detector is to compare the 1 kHz preset counter output to a 1 kHz reference signal from the Frequency Divider Module. As a result of this comparison, a dc voltage is generated proportional to the amount of phase difference. The circuit

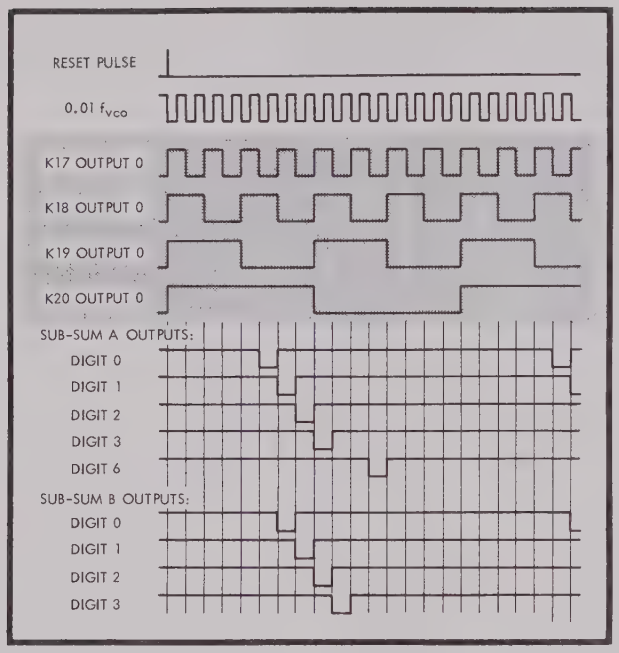


Figure 3-19. FIRST-DIGIT COUNTER OUTPUT STATES TO THE SUMMING BUS

diagram is shown in simplified form in Figure 3-20. The complete circuit is depicted on Drawing No. 207-1-124.

3-107. The negative-going 1 kHz summing bus waveform is inverted through K22A to trigger the reset multivibrator. Two-input gate K22 and buffer amplifier K21 are the active elements of this multivibrator. The output pulse, in turn, triggers a 900-usecond one-shot multivibrator to its high state. This multivibrator returns to its low state after 900 useconds, preparatory to the next 1 kHz triggering pulse. The active elements of this multivibrator are Q11, Q12, Q13 and Q14. The output signal is connected to the base of Q1 through diode CR2.

3-108. The 1 kHz reference signal from the frequency divider is inverted through K7A to trigger a 50-usecond one-shot multivibrator. Here, the negative-going excursion of the 1 kHz reference signal triggers the multivibrator output to its high state, where it remains for 50 useconds. After 50 useconds, the output returns to its low state for 950 useconds. This signal is inverted in K8A for connection to the base of Q1 through diode CR3.

3-109. The comparison of the two signals at the base of Q1 is illustrated in Figure 3-21. When the 1 kHz sum-

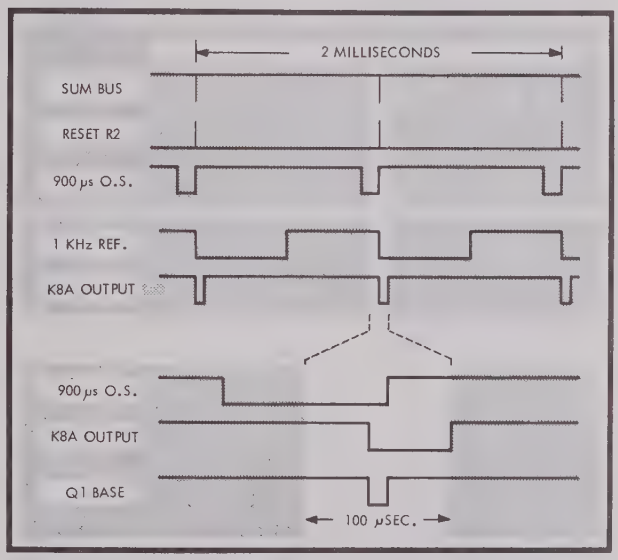


Figure 3-21. FREQUENCY SYNTHESIZER PHASE DETECTOR WAVEFORMS (ABOVE SERIAL NUMBER 225)

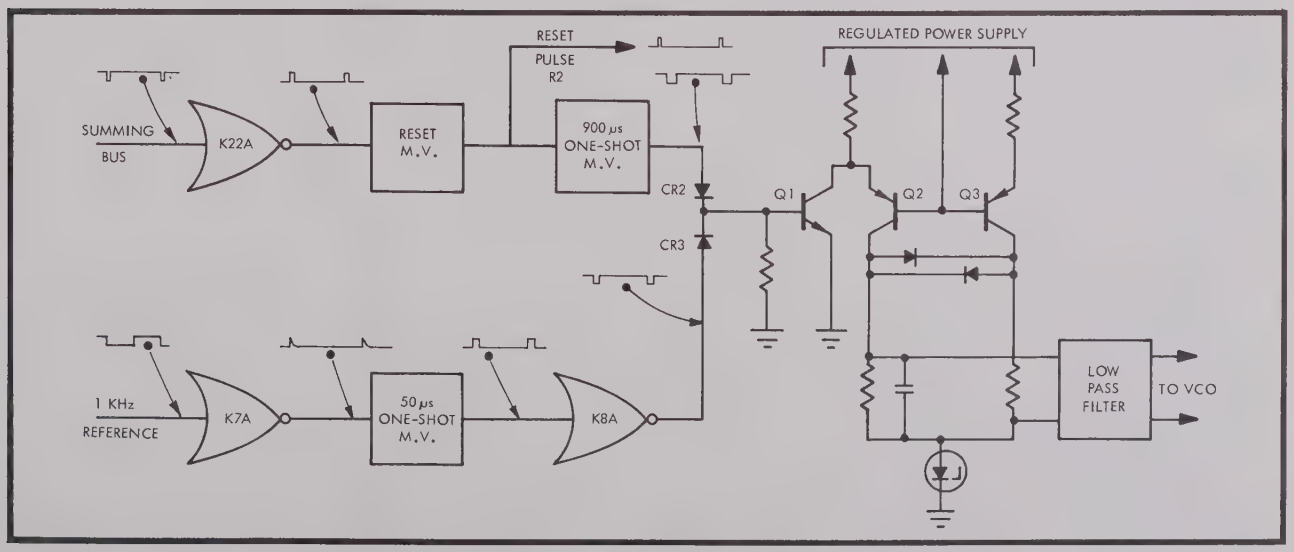


Figure 3-20. SIMPLIFIED FREQUENCY-SYNTHESIZER PHASE DETECTOR CIRCUIT DIAGRAM FOR INSTRUMENTS ABOVE SERIAL NUMBER 225

ming-bus pulse triggers the reset multivibrator, a positive reset pulse (R2) is generated. This pulse, in addition to triggering the 900-usecond one-shot multivibrator, also resets all of the flip flops in the preset counter. Circuit responses are fast and the positive-going excursion of the 900-usecond one-shot multivibrator output is coincident with the negative-going excursion of the preset-counter output pulse. The 1 kHz reference signal, meanwhile, triggers the 50-usecond one-shot multivibrator to result in another negative pulse at the base of Q1. However, in this case note that the negative-going excursion is of interest. In the expanded time scale at the bottom of Figure 3-21, the 900-usecond multivibrator positive-going excursion is shown to occur later than the negative-going excursion of K8A. This corresponds to the occurrence of the 1 kHz time reference before the negative-going excursion of the preset counter pulse. As the result of this time difference, the base of Q1 is pulsed negative.

3-110. The negative pulse at the base of Q1 turns off the transistor, allowing its collector to go positive to forward bias Q2. As Q2 conducts, the capacitance in its collector circuit is charged. The amount of charge is proportional to the amount of current flow in Q2, which in turn is proportional to the pulse width of the input signal to the base of Q1. As a result, the collector voltage of Q2 is proportional to the time difference between the occurrence of the preset counter pulse and the 1 kHz reference pulse.

3-111. Capacitor C2 in combination with the biasing resistor of buffer amplifier K21 determines the pulse-width of the reset multivibrator output. Initially, the 3.6 volts at the input to the buffer, holds the output and input 5 of K22B in the low state. Then, upon the arrival of the inverted summing-bus trigger, the output of K22B is switched to its low state. This action immediately switches the buffer output to its high state, reinforcing the switching action through input 5 of K22B. As C2 charges through the biasing resistor of the buffer amplifier, a point is soon reached where the output of K21 begins to drop. As K22B input 5 goes negative, the output goes positive, reinforcing the positive-going voltage at the input to K21 and terminating the pulse.

3-112. Transistors Q11, Q12, Q13 and Q14 are the active elements of the 900-usecond one-shot multivibrator. Initially, Q13 and Q14 are conducting. When Q11 is turned on by the reset pulse R2, its falling collector voltage is coupled to the base of Q14 through C4 and disconnect diode CR1. When Q14 turns off, its rising collector voltage turns on Q12 through R5, holding the base of emitter follower Q13 at its low state. During this initial switching action, the anode of CR1 goes sufficiently negative to back-bias the diode. Following the switching, C4 begins to charge through R8 and R9. When the anode of CR1 reaches a voltage sufficient to forward bias the diode, Q14 is turned on and Q12 turned off. This switching action occurs 900 useconds after the initial triggering. At this point the multivibrator has completed one cycle and is ready to receive the next triggering signal, which should follow in about 100 useconds.

3-113. The operation of the 50-usecond multivibrator is identical to that of the reset multivibrator excepting, of course, the duration of the pulse. In this case, capacitor C9 and resistor R17 determine the width of the output pulse.

3-114. Transistor Q6 functions as a regulated constant voltage source for the comparator pair Q2 and Q3. Transistors Q5 and Q4 in company with Zener diode CR9 function as a constant voltage source to bias the bases of Q2 and Q3. This degree of regulation is necessary to insure that the capacitance in the collector circuit of Q2 charges as a function of the input pulse width and not random power supply variations. Note also that transistor Q7 regulates the current to the 900-usecond one-shot multivibrator. This is to insure the stability of the multivibrator timing. Diodes cross connected between the collectors of Q2 and Q3 limit the output voltage during those periods of large time differences between the two pulses.

3-115. To insure proper synchronization between the voltage-controlled oscillator ten-to-one frequency divider and the comparison circuits, reset pulse generator K1 generates a resetting pulse every ten milliseconds. This is important for example, when the oscillator is switched to a new frequency. The 100 Hz output from the frequency divider is connected to K1 through transistor Q15. Note that input S of K1 is connected to +3.6 volts. K1 output 0 is reset to its high state by the pulses from the 50-usecond one-shot multivibrator. This condition sets input 2 of K24A in its high state, also; effectively blocking the reset pulse R2 (connected to K24A through K24B). When K1 is triggered by the 100 Hz signal, output 0 (and hence input 2 to K24A) is switched to its low state. This action permits one reset pulse (R2) to appear at the output of K24A before K1 output 0 is reset to its high state.

3-116. PHASE DETECTOR
(BELOW SERIAL NUMBER 225)

3-117. The operation of the phase detector in instruments below serial number 225 is different from other instruments only in the method of comparing the 1 kHz preset-counter output to the reference signal. The circuit differences are illustrated in Figure 3-22. Here, the summing-bus pulse triggers a reset multivibrator, as before, but the reset pulse triggers a 100-usecond one-shot multivibrator instead of a 900-usecond multivibrator. The multivibrator output is inverted in K22A for connection to the base of Q1.

3-118. The reference signal in instruments below serial number 225 is the 5 kHz output from the frequency standard instead of the 1 kHz. The signal is inverted in K2A and connected directly to the base of Q1.

3-119. The comparison of the two signals is illustrated by the waveforms of Figure 3-22. Here, the negative-going transition of the reset pulse (R2) occurs before the positive-going excursion of the inverted 5 kHz standard. As before, this time difference results in a pulse at the base of Q1. This pulse, turns off Q1, gating current through Q2 to the capacitive load.

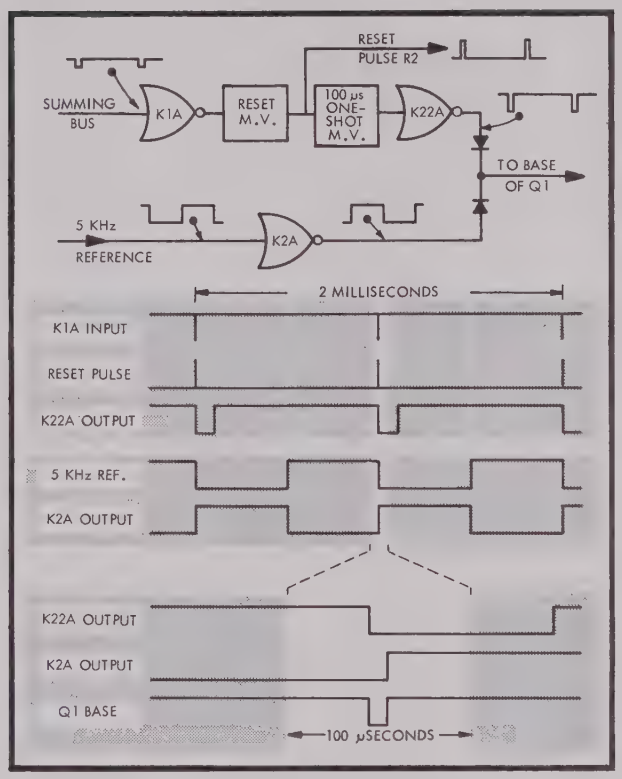


Figure 3-22. PHASE DETECTOR CIRCUIT AND WAVEFORMS FOR INSTRUMENTS FROM SERIAL NUMBER 112 TO 225

3-120. THE VLF RECEIVER

3-121. INTRODUCTION

3-122. The function of the vlf receiver is to receive the desired vlf standard signal amplify it, and covert it to 1.1 kHz without introducing objectionable phase distortion. The principle elements of the receiver are depicted in the block diagram of Figure 3-23. Specific circuit details are shown on the schematic diagrams of Drawing 207-1-115, -116 and -117.

3-123. The antenna selector switch at the input to the receiver permits selecting input characteristics appropriate to the type of antenna employed. When the Model 207-1-450 Whip Antenna is used, this circuit also provides dc power for the field-effect transistor mounted in the antenna base. The rf atennuator provides up to 60 db attenuation in 10 db steps. The narrow-band filters, when used, provide for the selective attenuation of undesired signals. As the title suggests, the broad-band amplifier amplifies all signals within the frequency range of the receiver. The first frequency conversion occurs in the 51.1 kHz Mixer Module. Here, the frequency synthesizer output is mixed with the incoming signal and the difference frequency amplified for conversion in the following stage. The choice of the "odd number" conversion frequency (51.1 kHz) is predicated on the need to avoid possible interference from strong "even number" frequencies (e.g. 10 kHz, 50 kHz, etc.) which are commonly prevalent in frequency and time standards laboratories. The second conversion takes place in the 1.1 kHz mixer in which a 50 kHz signal from the frequency divider (coherent with the frequency synthesizer output) is mixed with the 51.1 kHz signal. The difference frequency, 1.1 kHz is amplified in the if amplifier and connected to the electronic-servo phase detector. Because the local signals employed in the dual conversion are coherent with the frequency-divider signals, the phase detector senses only those phase shifts occurring in the received signal. The if amplifier output is additionally amplified in the audio amplifier for signal monitoring by loudspeaker.

3-124. THE ANTENNA INPUT CIRCUITS

3-125. The antenna input circuits are depicted on Drawing Number 207-1-117. The circuit elements are mounted on assemblies A25 and A35, the Antenna Selector Assembly and the Attenuator Assembly, respectively. When the whip antenna is used, the input circuits also include the components mounted in the antenna base, assembly A18. Referring to the schematic diagram, when the rear-panel ANTENNA switch, S11, is placed in the HI Z position, the signal path is through Q1. DC power is supplied through the signal connection to the attenuator. Q1 functions as an impedance-matching device, presenting a high-impedance characteristic to the antenna and a low-impedance to the attenuator. When the switch is placed in the 50-OHM position, the

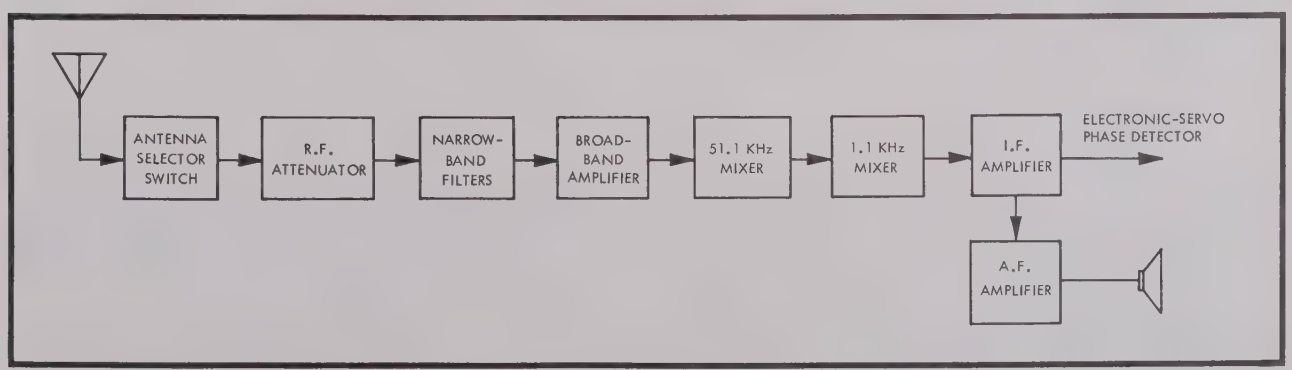


Figure 3-23. VLF RECEIVER BLOCK DIAGRAM

signal connection is directly to the antenna through C2 providing a 50-ohm input impedance at the antenna input connector. When the switch is placed in the WHIP antenna position, the antenna input is connected through the interconnecting coaxial cable to Q1 in the base of the antenna. As in the Antenna Selector Assembly, Q1 is an impedance-matching device to match the high impedance of the antenna to the 50-ohm transmission line. DC power for Q1 is connected through R19 on the Attenuator Assembly from the -13-volt connection on the 1.1 kHz Mixer Assembly. The wiring connection is completed through A14-P21, A13-P20 and A12-P19. As a result, removing one of the modules will interrupt the power connection to Q1.

3-126. The attenuator is a six-section, resistive "T" attenuator in which successive sections are switched into the circuit as the front-panel RF ATTENUATION switch (S7) is advanced from 0 to 60. The attenuator output is connected through the RF FILTER switch (S8) to connectors XP22 through XP25. These connectors are provided for the addition of narrow-band, rf filters to reject interfering signals. Filters are not normally supplied with the instrument and must be ordered by specifying the desired passband frequency.

3-127. THE BROADBAND AMPLIFIER

3-128. Two frequency-selective circuits are employed in the input circuit of the broadband amplifier. One is the series combination of L/C filters C4/L1/C5 and L2/C12. The L/C ratios of this circuit result in a band-pass from 8 kHz to 31.9 kHz. The second frequency-selective circuit is the combination of T1/C2 and T2/C3, tuned to 60 kHz. Signals within these frequency limits are amplified by grounded-base amplifier Q2 and collector-loaded amplifier Q3. Transistor Q1 functions as a constant-current source for Q2. That is, as the current increases in Q2 and Q1, the voltage drop across R3 also increases, tending to reduce the forward bias and, therefore, Q1 conduction. The net effect is a tendency for Q1 to regulate a constant amount of current through Q2. This current-limiting action insures symmetrical amplifier response centered on the no-signal operating point. As a result, the zero-axis crossing of the input signal (and hence the phasing of the signal) remains constant over a wide range of input voltages. To prevent feed-through of strong 51.1 kHz signals, two parallel-tuned L/C filters modify the amplifier frequency response. Inductors L4 and L5 with their associated capacitors are tuned to 51.1 kHz. The resultant amplifier frequency response is depicted in Figure 3-24.

3-129. THE 51.1 KHZ MIXER

3-130. The broadband-amplifier output is connected to the 51.1 kHz mixer through pins 1 and 2 of P20. The first stage of the mixer is a differential amplifier consisting of Q1 and Q2. Transistor Q3 functions as a constant-current source. The amplifier output is connected to mixing transistors Q4 and Q5 through band-pass filters L1/L2 and L3/L4. These filters serve to reject undesired signals above 60 kHz and below 8 kHz. The frequency synthesizer output is connected through transistors Q7 and Q6 to the emitter circuits of mixers Q4

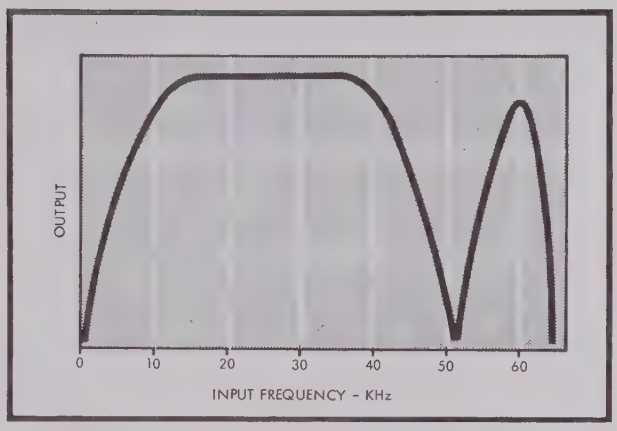


Figure 3-24. BROADBAND AMPLIFIER FREQUENCY RESPONSE

and Q5. The synthesizer output is a square wave in the frequency range from 59.1 to 83.0 kHz and 111.1 kHz. The exact frequency, of course, is selected with the FREQUENCY/KHZ controls. This square wave alternately turns Q6 off and on, resulting in pulsed collector currents in Q4 and Q5. In the collector load, T1, the difference frequency ($f_{synth.} - f_r = 51.1$ kHz) is selected for coupling to the 1.1 kHz Mixer Module through tuned-transformer T2.

3-131. THE 1.1 KHZ MIXER

3-132. In the 1.1 kHz Mixer Module, there are two stages of amplification preceeding the second-conversion mixer. Transistors Q1, Q2, Q4 and Q5 operate as differential amplifiers. Transistors Q3 and Q6 function as constant-current sources. In the mixer stage, the 50 kHz square wave from the frequency divider is connected to the emitters of Q7 and Q8 through Q10 and Q9. The output is connected directly to the if amplifier through pins 3 and 4 of P19.

3-133. THE IF AMPLIFIER

3-134. The 1.1 kHz input to the if amplifier includes all four frequency products of the second-conversion mixing. At the input to the amplifier, two dual-section low-pass filters reject the three highest frequency components. The filters, L1, L2, L3 and L4 and their associated capacitors are tuned for maximum rejection of the undesired signals. The 1.1 kHz signal is amplified in three stages of differential amplifiers. Transistors Q11, Q14 and Q18 function as constant-current sources for their associated stages. During normal operation, Q16, CR1 and CR2 are turned off. When it is desired to blank (that is, turn off) the output signal, terminal 4 of P5 can be grounded, turning on Q16. This action also turns on diodes CR1 and CR2, biasing transistor pairs Q10/Q12 and Q15/Q13 into cutoff and disabling the amplifier. Note that the output signals at pins 18 and 19 of P5 are the inverse complement of each other. That is, they are 180° out of phase.

3-135. The 1.1 kHz signal at the collector of Q10 is amplified by audio drivers Q8 and Q9 for connection to

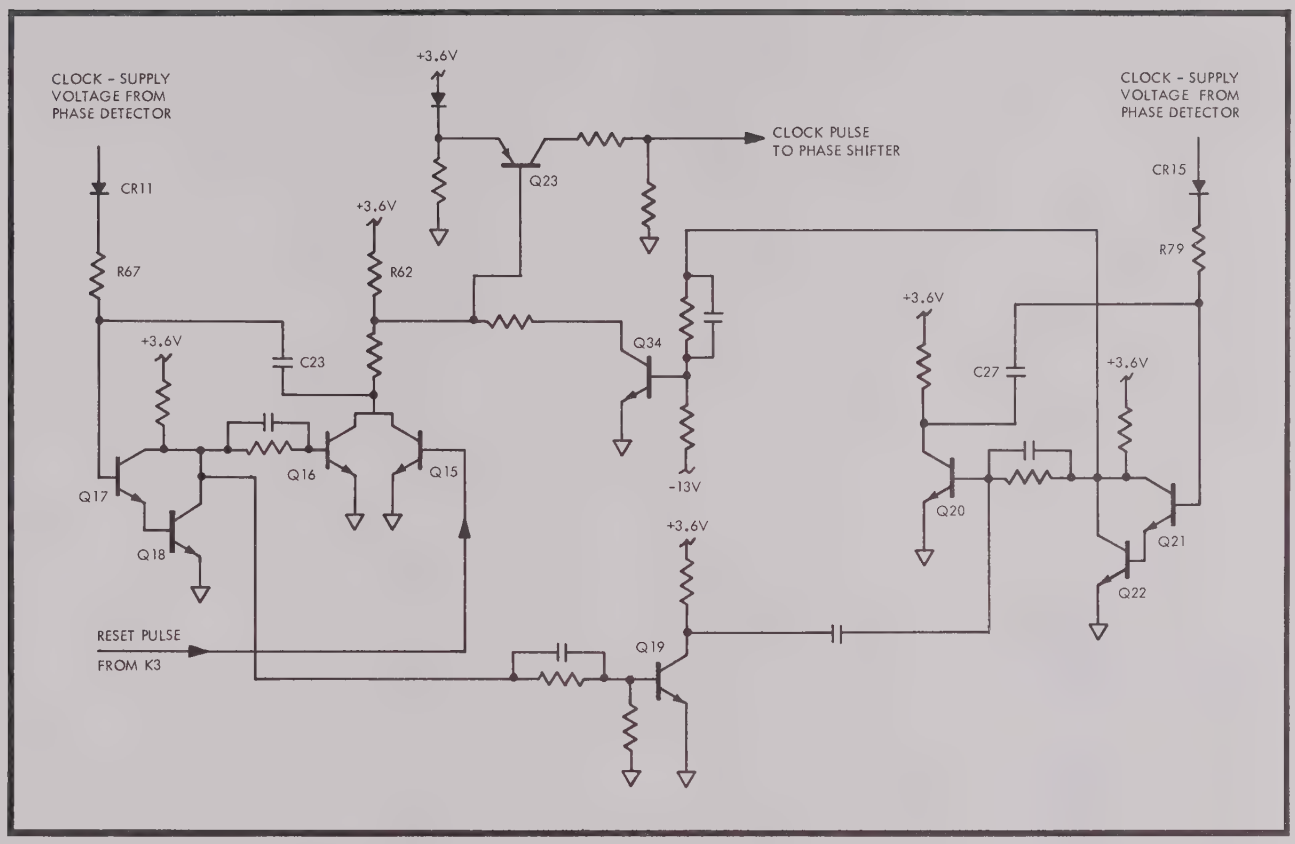


Figure 3-25. SIMPLIFIED VARIABLE-RATE TIMING CLOCK SCHEMATIC

the rear-panel 1.1 KHZ IF OUTPUT connector, J15. The RC network, R33/C11/R34 connected to the collector of Q12 simulates the amplifier loading of Q10 to preserve balanced, differential-amplifier operation. The audio driver output is also connected to the audio amplifier, Q2, Q3, Q4, Q5 and Q6 to drive the loudspeaker for audio monitoring of the received signal.

3-136. ACCUMULATIVE - ERROR READOUT

3-137. INTRODUCTION

3-138. The function of the accumulative-error readout circuit is to tally the net amount of phase-shift increments necessary to maintain coherence between the frequency-divider output and the received vlf frequency standard. In response to clock pulses from the variable-rate clock, the electronic-servo phase shifter advances or retards the phase in 1 microsecond increments. Coincidentally, the mechanical counter on the front-panel advances or retards the same number of increments. The variable-rate timing clock and the accumulator drive circuits are shown schematically on Drawing Number 207-1-103. Circuit components are located on assembly A6, the Phase Shifter Module.

3-139. THE VARIABLE-RATE CLOCK

3-140. A simplified schematic diagram of the variable-rate clock is shown in Figure 3-25. The principle elements of the clock are two multivibrators, Q15 thru Q18 and Q20 thru Q22. The clock-rate determining elements are capacitor C23 in company with the resistor designated R67 in Figure 3-25, and C27 in company with R79. Transistors Q34 and Q19 are feedback amplifiers to cross-connect the two multivibrators. The reset pulse to the base of Q15 originates in the phase shifter and occurs at the completion of an incremental shift in phase (see paragraph 3-40). The clock-supply input voltage to diodes CR11 and CR15 originates in the Phase Detector Module and is proportional to the amount of phase difference. (See paragraph 3-88.)

3-141. The operation of the variable-rate clock is illustrated by stylized waveform in Figure 3-26. The clock cycle is initiated by the reset pulse from K3 in the phase shifter. This positive pulse turns on Q15. The falling collector voltage is coupled through C23 to the base of Q17, turning off Q17 and Q18. The positive excursion at the collector of Q17 and Q18 is amplified and inverted through Q19 to trigger the other multivibrator. The negative-going signal at the collector of Q19 is coupled to the base of Q20, turning it off. Meanwhile, the voltage at the base of Q17 begins to rise due to the charging of C23 through resistor R67. When the base voltage reaches approximately 1.2 volts, transistors Q17 and Q18 are forward biased and go into conduction. This switching action is coupled to the base of Q16, turning it off. Simultaneously, Q19 is turned off resulting in a positive-going voltage at the base of Q20, turning it on.

The falling collector voltage is coupled to the base of Q21 through C27, turning off Q21 and Q22. When Q21 and Q22 turn off, a positive-going voltage is coupled to the base of Q34, turning it on. This action keeps Q23 forward biased, transferring the current through R62 from Q16 to Q34. Following the switching, the base voltage of Q21 begins to rise due to the charging of C27 through R79. When C27 charges sufficiently to forward bias Q21, transistors Q21 and Q22 are turned on, reverting the multivibrator. The falling voltage at the collectors of Q21 and Q22 is coupled to Q34, turning it off. This action switches the base of Q23 sufficiently positive to turn it off also. As a result, the collector voltage drops, initiating a clock pulse to the phase shifter. After the phase shifter has completed its phase shifting action, another reset pulse appears at the base of Q15 triggering the next clock cycle.

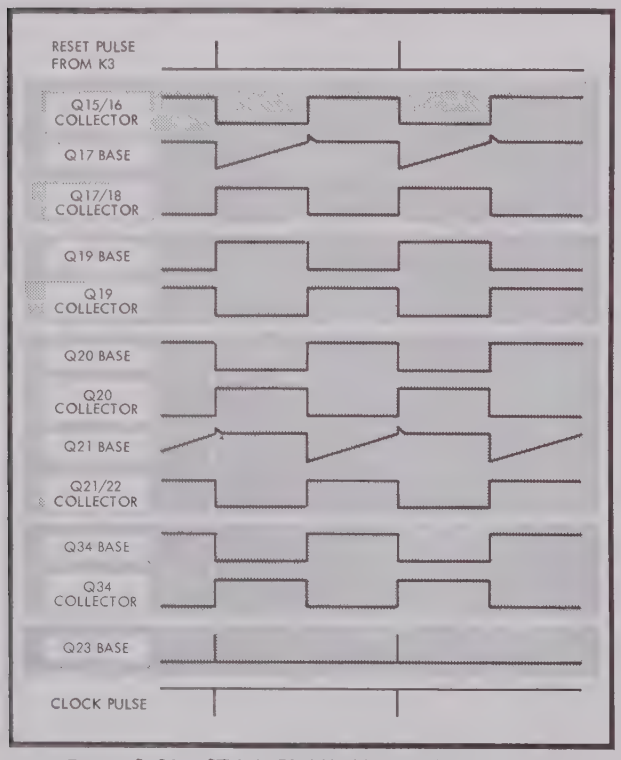


Figure 3-26. STYLIZED VARIABLE-RATE CLOCK WAVEFORMS

3-142. From the preceeding discription it is evident the interval between clock pulses is dependent upon the charge rates of C23 and C27. These capacitors charge through resistors selected with the TRACKING RATE switch. Referring to Drawing No. 207-1-103, C23 is charged through R64 and R86 when the switch is placed in the 1 X 10^{-6} position. Similarily, C27 is charged through R76 and R86. And in a like manner, the capacitors are charged through other values of resistance when the switch is advanced to other positions. Note that the anodes of the series diodes are connected to -13 volts for back-biasing when not selected with the switch. However, the value of series resistance is not the only element that determines the charge rate and hence the elapsed time between clock pulses. Recall that the dc clock-supply voltage is proprotional to the amount of phase difference. The method by which the variable voltage determines the switching interval is illustrated in Figure 3-27. Here the charge rate of a 33 microfarad capacitor is plotted twice; once for an input voltage (E) of 5 volts and once for an input voltage of 7 volts. In both cases, the capacitor is charging through a 5 kilohm resistor. The RC time-constant is 165 milliseconds. In the case of the 5-volt charging voltage, the capacitor would reach approximately 0.6 of this value, or 3.1 volts in 165 milliseconds. In the case of the 7-volt charging voltage, it would reach a value of 4.3 volts in the same interval. However, in the first case the voltage would reach a value of 1.2 volts (the forward-bias voltage of transistor Q17 and Q21) in approximately 50 milliseconds point A in Figure 3-27), whereas with a seven-volt charging voltage it would reach the same value in approximately 35 milliseconds (point B). Because the capacitor charges to 1.2 volts more rapidly when the charging voltage is higher, the elapsed time between clock pulses is shorter when the phase difference is large.

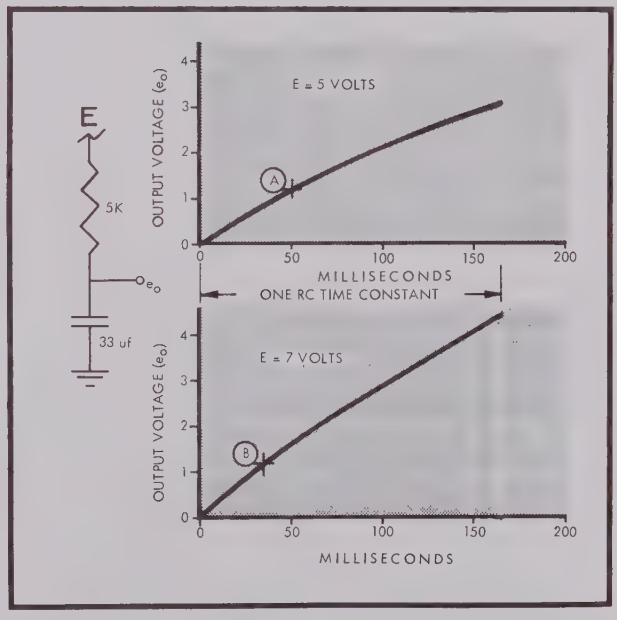


Figure 3-27. ILLUSTRATING THE VOLTAGE-DEPENDENT CHARGE RATE OF A CAPACITOR

3-143. THE ACCUMULATOR DRIVER

3-144. The accumulator driver circuits sense the direction of phase shifts in the phase shifter and tally the increments on the front-panel mechanical counter. An important characteristic of this circuit is that it will respond only to the second and succeeding incremental steps following a change in the direction of phase shifting. This characteristic prevents chattering of the mechanical counter when the phase shifter is "tracking" very closely and alternately adding and deleting phase increments. The complete accumulator-driver cir-

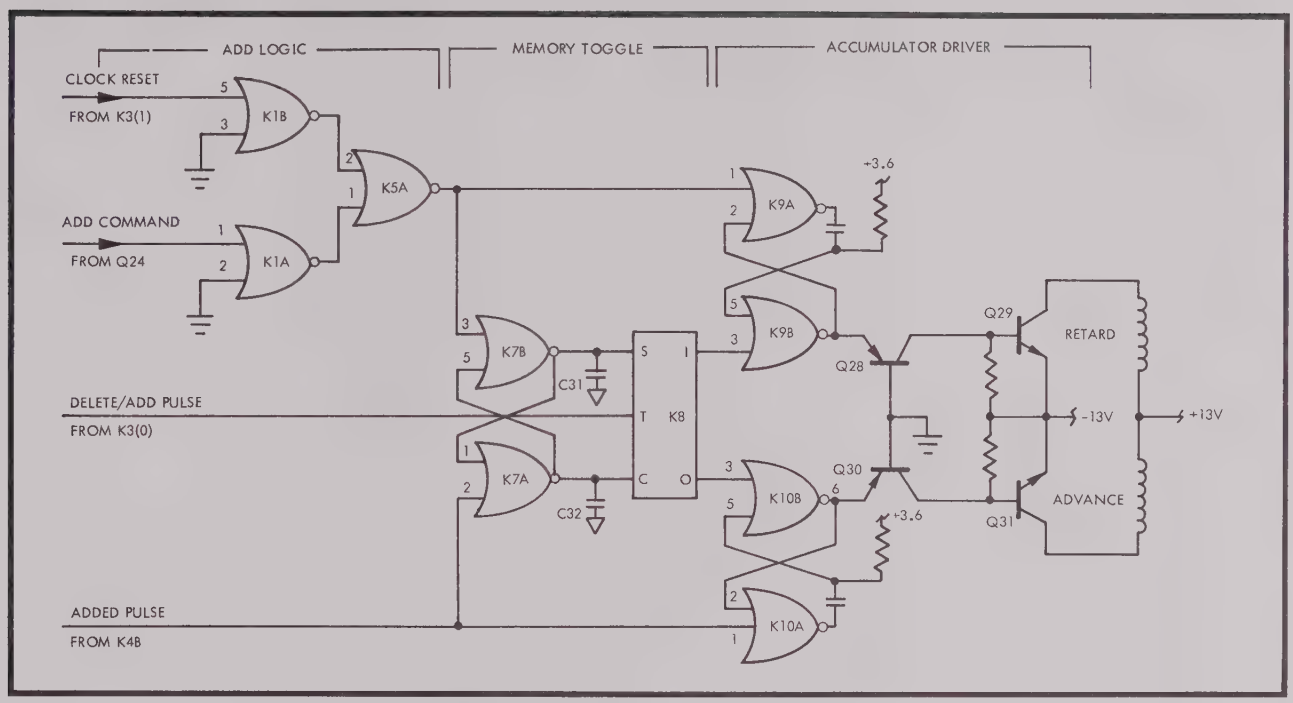


Figure 3-28. SIMPLIFIED ACCUMULATED-ERROR READOUT CIRCUIT

cuit is shown on the phase shifter schematic diagram, Drawing Number 207-1-103. A simplified diagram is depicted in Figure 3-28.

3-145. In the explanation that follows it is assumed the phase shifter is adding phase increments at the outset, followed by a transition to deleting phase increments. This is portrayed by the changing dc level of the add-command signal in Figure 3-29. The clock reset pulse, of course, occurs at the completion of each phase shift increment at a rate determined by the variable-rate clock. In Figure 3-29 it is depicted as a periodic pulse for simplicity. The add pulse from K4B occurs every time the phase shifter adds a phase increment. And similarily, the delete/add pulse occurs every time the phase shifter adds or deletes a phase increment.

3-146. During the time the phase shifter is adding phase increments, input 1 of K5A is held in its high state by the add command signal from Q24, inverted through K1A. This condition holds the output in its low state, preventing the transmission of the clock reset pulse to K7B and K9A. However, when the add command is removed and K1A input 1 goes positive, K5A input 1 is switched to its low state gating the clock reset pulse to input 3 of K7B. Upon the arrival of the first clock-reset pulse following the transition to the delete command, K7B output is switched to its low state, switching K7A output to its high state. This action also switches input S of K8 to its low state and input C to its high state; the reverse of the conditions that existed during the add-command interval. However, note that both inputs are capacitively loaded with capacitors C31 and C32. This loading delays the switching action until after the occurrence of the triggering signal. Following this, the second delete/add pulse triggers K8, switching its out-

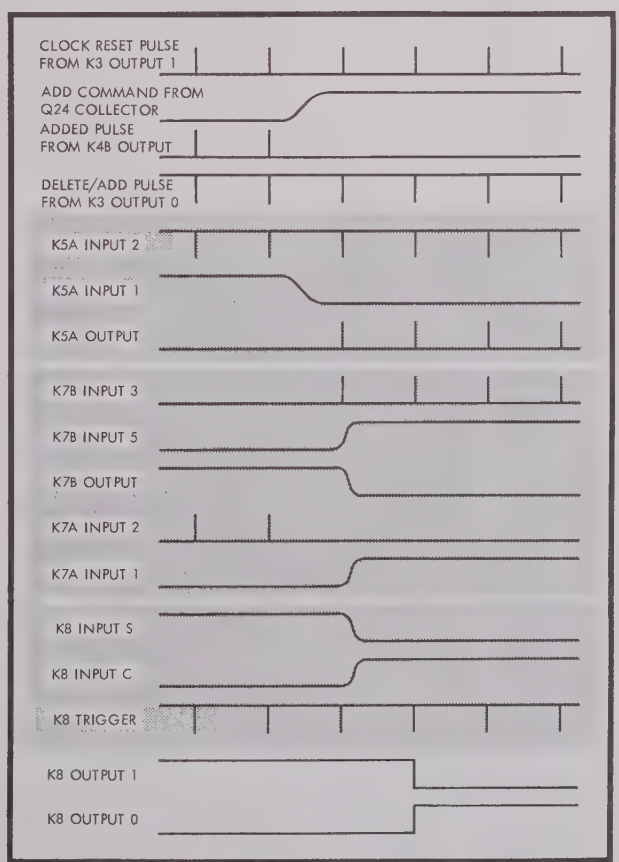


Figure 3-29. ACCUMULATOR MEMORY-TOGGLE WAVEFORMS

puts to their other state. Similar switching occurs when the phase shifter makes a transition from deleting increments to adding increments. However, in this case cross connected K7A and B are switched by the added pulse from K4B.

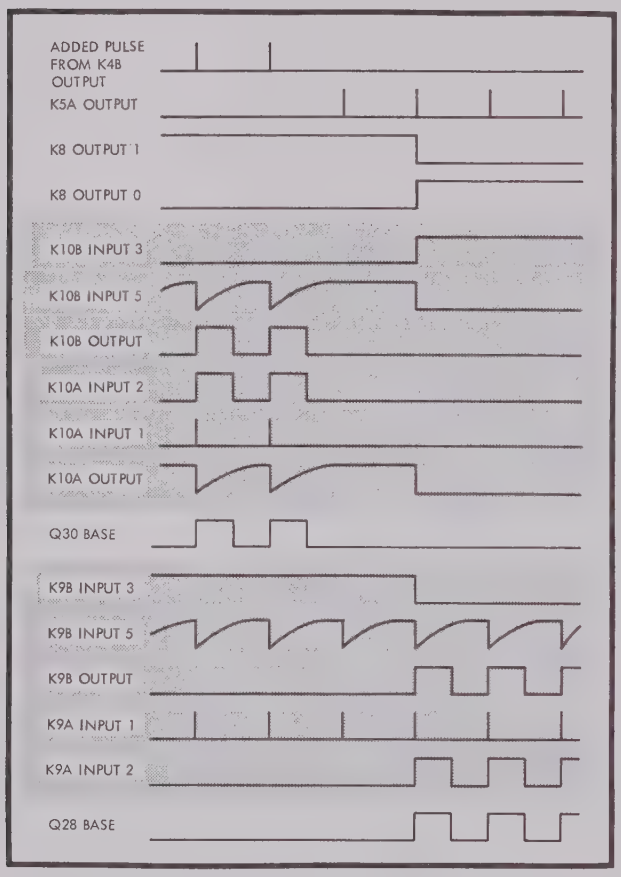


Figure 3-30. ACCUMULATOR-DRIVER WAVEFORMS

3-147. The toggling of K8 reverses the input conditions to K9B and K10B. The circuit functions of these devices are depicted by stylized waveform in Figure 3-30. During the time the phase shifter is adding phase increments, K8 output 1 and K9B input 3 are in their high state. This condition backbiases transistor Q28 preventing current flow through the mechanical-counter retard coil and Q29. Conversely, K8 output 0 keeps input 3 of K10B in its low state permitting the one-shot multivibrator K10B/K10A to be triggered. The triggering signal is the added pulse from K4B. Each added pulse triggers the multivibrator, turning on Q30 which in turn energizes the advance coil of the mechanical counter through Q31. (The waveforms of Figure 3-30 are exaggerated for clarity and should not be considered typical of the time scale in the instrument.) When the phase shifter ceases to generate added pulses, multivibrator K10A/K10B, or course, is not triggered and the advance coil is not energized. However, the first deletion of a phase increment (followed by the reset pulse) switches K8 to its other state. Then, the next reset pulse triggers K9A, energizing the retard coil through Q28 and Q29.

3-148. RELATIVE-TIME READOUT

3-149. READOUT TIME-SPAN LOGIC

3-150. The function of the relative-time readout circuits is to record on a strip-chart recorder the frequency differences between the received vlf frequency standard and the local frequency standard. A simplified diagram of the circuits is shown in Figure 3-31. Complete circuit details may be found on Drawing Number 207-1-104. The input signals are symmetrical squarewaves; one derived from the local frequency standard and the other from the frequency divider. The 100 kHz frequency-standard waveform is connected to input 3 of K6A and, through a ten-to-one frequency divider, to input 7 of K6B. Inputs 1 and 8 of K6A and B are connected to the SPAN switch, S6. When the switch is in the 10-usecond position, input 8 of K6B is elevated to its high state; blocking the transmission of the 10 kHz signal from the frequency standard. Conversely, when the switch is in the 100 usecond position, input 1 of K6A is held in its high state, blocking the transmission of the 100 kHz signal. The SPAN switch also selects either 100 kHz or 10 kHz on the Frequency Divider Module in a similar manner. (See paragraph 3-70.)

3-151. When the SPAN switch is set at 100 useconds, the 10 kHz frequency-standard signal is coupled through K7B and Q12 where it is inverted. Positive excursions of this signal reset output 0 of K8 to its high state. The 10 kHz square wave from the frequency divider is connected to the trigger input of K8. Because the set terminal is biased to 3.5 volts, negative transitions of this signal will switch K8 output 0 to its low state when the reset terminal is in its low state. If there is no phase difference between the two signals, the positive half-cycle of the reset signal will be coincident with the negative half-cycle of the triggering signal (remember, the frequency standard signal is inverted in Q12). The reset voltage, of course, will determine the output state of K8 and output 0 will remain in its low state. However, should the triggering signal lead the reset signal, K8 output 0 is switched to its low state by the triggering signal, and then reset to its high state by the reset signal. And similarily, if the triggering signal lags the reset signal, K8 output 0 is switched to its low state immediately following the return of this comparison is a negative-going pulse at the base of Q19, the time duration of which is proportional to the phase difference between the two signals.

3-152. When Q19 is conducting (that is, when K8 output 0 is in its high state), Q17 is turned off and there is no charging current to C15. Conversely, when Q19 is turned off by a negative-going pulse from K8, Q17 is forward biased and C15 is charged at a constant rate. As a result, the voltage output to the meter of the strip-chart recorder is proportional to the time duration of the pulse at the base of Q19.

3-153. Referring to Drawing Number 207-1-104, note that there are two identical output circuits; one for the

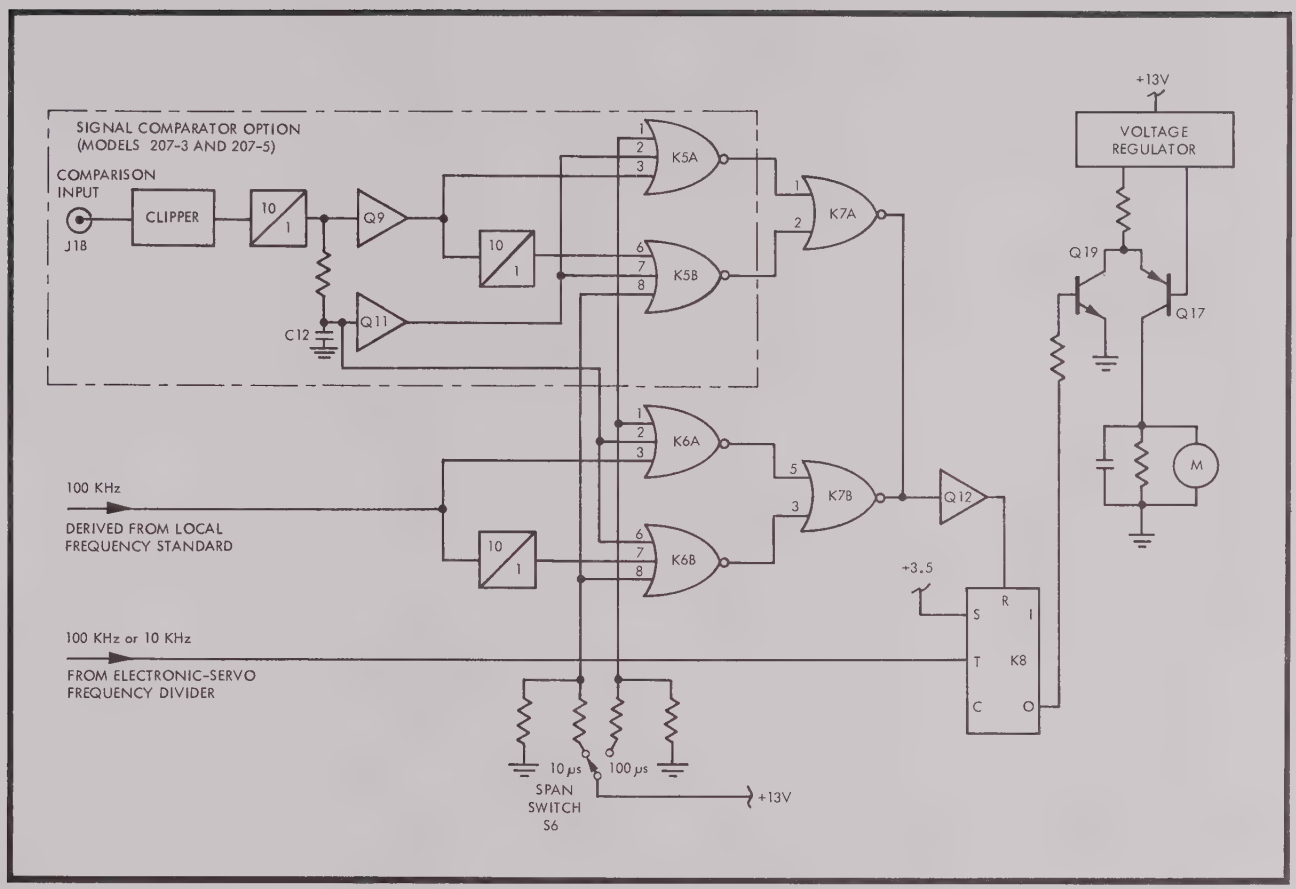


Figure 3-31. SIMPLIFIED RELATIVE-TIME READOUT CIRCUIT DIAGRAM

front-panel chart recorder and one for a remote chart recorder with connections through the rear-panel 10-terminal barrier strip. The jumper option at the output of K8 provides for reversing the readout scale of the chart recorders.

3-154. OPTIONAL SIGNAL COMPARATOR

3-155. In the Models 207-3 and 207-5, a signal comparator is provided for comparing local signals with the received frequency standard. The circuit elements are located on the Readout Module and portrayed schematically on Drawing Number 207-1-104. A simplified schematic diagram is included in Figure 3-31. The signal comparator circuit will accept signals in the range from 100 kHz to 1 MHz in 100 kHz increments. The signal is standardized to a 100 kHz pulse in the n/1 divider and amplified in Q9 for connection to the comparison circuits through K5A or K5B. When a signal is connected to the comparison input, capacitor C12 is charged by the output signal from the n/1 divider. The resulting positive voltage is connected to inputs 2 and 6 of K6A and B to disconnect the local frequency standard from the comparison circuits. As with the local frequency standard signals, the SPAN switch energizes inputs to K5A or B to select either the 10 kHz or the 100 kHz signal for comparison.

3-156. SIGNAL - LIGHT READOUT

3-157. INTRODUCTION

3-158. The function of the three front-panel signal lamps is to signal incorrect system operation. Two of the lamps, when illuminated, indicate incorrect signal conditions. The third indicates settings of the FREQUENCY/KHZ controls to frequency outside the range of the receiver. In the case of the incorrect-signal indicators, there are two principle circuits; a signal phase detector on the Phase Detector Module (Drawing No. 207-1-101) and the signal-lamp logic circuits located on the Readout Module (Drawing No. 207-1-104). The switching circuits for the invalid-frequency lamp are located on the Preset Counter E Assembly (Drawing No. 207-1-124).

3-159. THE SIGNAL PHASE DETECTOR

3-160. The function of the signal phase detector is to sense those signal conditions necessary to maintain phase lock between the electronic servo and the received signal. Circuit operation is very similar to that of the servo phase detector. (See paragraph 3-73.) The 1.1 kHz signal from the if amplifier is connected to the base of Q34A and the 1.1 kHz signal from the frequency divider is connected to the common emitter circuit

through Q32, Q31 and Q30. However, the signal at this point is displaced from the corresponding signal in the servo phase detector by 1/4 cycle (90°). As a result, Q30 is turned on coincident with the positive half cycle of the 1.1 kHz if signal. Under these conditions, Q34A and Q34B conduct during the entire half cycle, charging capacitors C24 and C28 of the operational integrator to their maximum value very quickly. These capacitors remain charged as long as the two input signals maintain the correct phase relationship for proper phase tracking in the electronic servo. The output signal from the integrator is coupled through emitter follower Q25 to output transistors Q23 and Q24. The output from Q23 is connected through the meter function switch S2 to the front-panel meter. When the switch is placed in the RF SIG position, the meter indicates the signal strength. The output from Q24 is connected to the no-lock logic circuits on the Readout Module. The operational integrator output is also connected to the base of Q27 so that when the signal phasing is correct, Q27 is turned off, causing its collector voltage to rise. The combination of this voltage and a corresponding voltage in the servo phase detector forward biases diodes CR1 and CR2. This energizes the no-signal logic circuits through pin 7 of connector P1.

3-161. NO-LOCK/NO-SIGNAL LOGIC CIRCUITS

3-162. When the servo phase detector and the signal phase detector output voltages fall because of incorrect input signal conditions, this falling voltage is coupled through pin 19 of P4 to the base of Q21, turning it off. The rising voltage at its collector is coupled through emitter-follower Q22 to the base of Q24. When Q24 is forward biased, it permits current flow through DS2, the NO-SIGNAL lamp. The current return path is through pin 22 and R59 to +13 volts.

3-163. When the phase relationship between the received signal and the electronic servo signal is incorrect for proper phase tracking, the signal phase detector output voltage falls, turning off Q26 through pin 11 of P4. The rising collector voltage of Q26 is coupled through emitter-follower Q27 to the base of Q29, turning it on. The NO-LOCK lamp in the collector circuit of Q29 is energized, when Q29 is turned on, through pin 10 and R70.

3-164. In the Model 207-3 and 207-5, the NO-SIGNAL lamp is also energized when a signal is connected to the front-panel COMPARISON INPUT connector. As explained in paragraph 3-155, capacitor C12 is charged by the application of an input voltage and this voltage is coupled through Q10 to energize the no-signal circuits. Also note that a falling voltage at the collector of Q26 brought about by the absence of correct phasing is also coupled to the no-signal circuits through Q25. This circuit configuration is necessary to account for the possibility that the servo phase detector may generate a phasing-error signal in response to noise and a signal-level below the operating threshold of the instrument.

3-165. In some applications, it is desirable to have an indication of incorrect operation at a point remote from the instrument. For this purpose, a signaling device can be connected to the rear-panel terminal strip to pin 16 of P4. The circuit is energized by Q28 or Q23. When either the NO-SIGNAL lamp or the NO-LOCK lamp is energized, these transistors are turned on by current flow through resistors connected to their respective bases (R59 and R70).

3-166. THE POWER SUPPLY

3-167. INTRODUCTION

3-168. In the Models 207-1, and 207-3, there are five regulated power supplies. In the Model 207-4 and 207-5, an additional regulated supply is added for the internal 1 MHz frequency standard, assembly A15. Two of the power supplies, the +13 volt and the -13 volt are located on the Power Supply Module. Three of the supplies, all of which supply 3.6 volts, are located on individual assemblies at convenient locations on the Chassis Assembly. All of the supplies are shown schematically on Drawing Number 207-1-106.

3-169. TRANSFORMER PRIMARY CIRCUIT

3-170. Input power to the power-supply transformer is effected through a three-wire power cord. At the point where the power cord enters the chassis, two high-voltage capacitors, C5 and C6, are connected between the power lines and chassis ground. These capacitors effectively block the introduction of undesired rf signals to the instrument circuits. Both sides of the power line are fused with 3/4 ampere fuses for 115-volt operation. For 220-volt operation, they must be changed to 3/8 ampere fuses. The primary of the transformer is wired at the factory for 115-volt operation. For 230-volt operation, jumpers between the transformer terminals must be changed as shown on the schematic. The chart recorder is connected between terminals 1 and 3 of the transformer at all times. When the instrument is operated on 220-volt power, the transformer primary functions as a voltage divider to provide 110 volts to the chart-recorder motor.

3-171. THE +13- AND -13-VOLT SUPPLIES

3-172. The +13- and -13-volt power supplies are identical except for output grounding. In the case of the +13-volt supply, the output from the series-regulating transistor is connected to the +13-volt bus. In the -13-volt supply it is connected to the chassis common. In the explanation that follows, the operation of the +13-volt supply is described. It, of course, applies equally well to the -13-volt supply.

3-173. There are two feedback loops in the +13-volt regulator. One is a voltage feedback loop to regulate the output voltage. The other is a current-sensing feedback path to protect the series transistor in the event of extreme overload. In the voltage-feedback loop, a voltage proportional to the power-supply output voltage is developed at the base of Q5 by voltage-divider R14/R15/R16. Q5 is one half of the differential amplifier; the other half being transistor Q4 with its base voltage fixed by Zener diode CR6. When the output voltage tends to fall below the desired value, the voltage at the base of Q5 also falls, tending to decrease conduction in Q5 and increase conduction in Q4. This action results in a

rising voltage at the collector of Q5 which is coupled through Q3 to the base of A1 Q1. As the base voltage of A1 Q1 rises, the conduction of the transistor increases, reducing the voltage drop across the device. This reduced voltage drop results in an increased voltage at the output to compensate for the original decrease sensed at the input to Q5. Current in the +13-volt supply is sensed by R11, developing a voltage at the base of Q2 proportional to the magnitude of the current. When this voltage reaches a value sufficient to turn Q2 on, its falling collector voltage is coupled through Q3 to the base of A1 Q1. This negative-going voltage tends to turn off A1 Q1, limiting current flow in the power supply load. The value of R11 and therefore the threshhold of current limiting has been selected to accomodate normal current requirements and variations in the instrument.

3-174. THE +3.6 VOLT POWER SUPPLIES

3-175. At convenient locations on the chassis, three regulating circuits provide +3.6 volt to the signal circuits. These regulators are designated assemblies A20, A21 and A22. They receive their input power from transformer T1 terminals 6 and 5 through bridge rectifier CR1 through CR4. The series regulating transistor in each of the regulators is designated Q5. (To effect adequate heat dissipation, the transistors are mounted on the chassis directly above the printed-circuit assembly.) Voltage regulation for these circuits is effected with a Zener Diode, CR1, connected between the +13-volt bus and ground. The Zener diode output voltage is connected to the base of Q5, maintaining an output voltage of 3.6 volts at the emitter.

3-176. EXTERNAL-BATTERY OPERATION

3-177. When it is desired to maintain system operation during a power line failure, an external battery may be connected to the power supply output circuits through connections on the rear-panel. The negative terminal of the external 26-volt battery is connected to the -13-volt bus through diode CR3. The positive terminal of the battery if connected to the +13-volt bus through CR1. During normal power-line operation, diodes A20 CR1 and A1 CR3 are back biased by the power supply output voltages. When the power-line voltage is removed, the battery voltage forward biases the diodes, permitting current flow in the load. Transistor Q4 provides for +7-volts power to the +3.6-volt regulators.

3-178. OPTIONAL BATTERY POWER SUPPLY

3-179. In the Models 207-4 and 207-5, the internal frequency standard is powered from the +13-volt and the -13-volt power supplies. In this case jumper B connects L1 to the +13-volt bus. However, both instruments can be modified for operation from internal rechargeable batteries. In this case, the model number is modified by the addition of the suffix B and the circuits enclosed in the dashed line marked "207-4B option" are added to the Power Supply Module. These circuits are shown in the simplified diagram of Figure 3-32.

3-180. There are three principle current paths illustrated in Figure 3-32. I_1 is the current path for supplying regulated voltage to the frequency-standard cir-

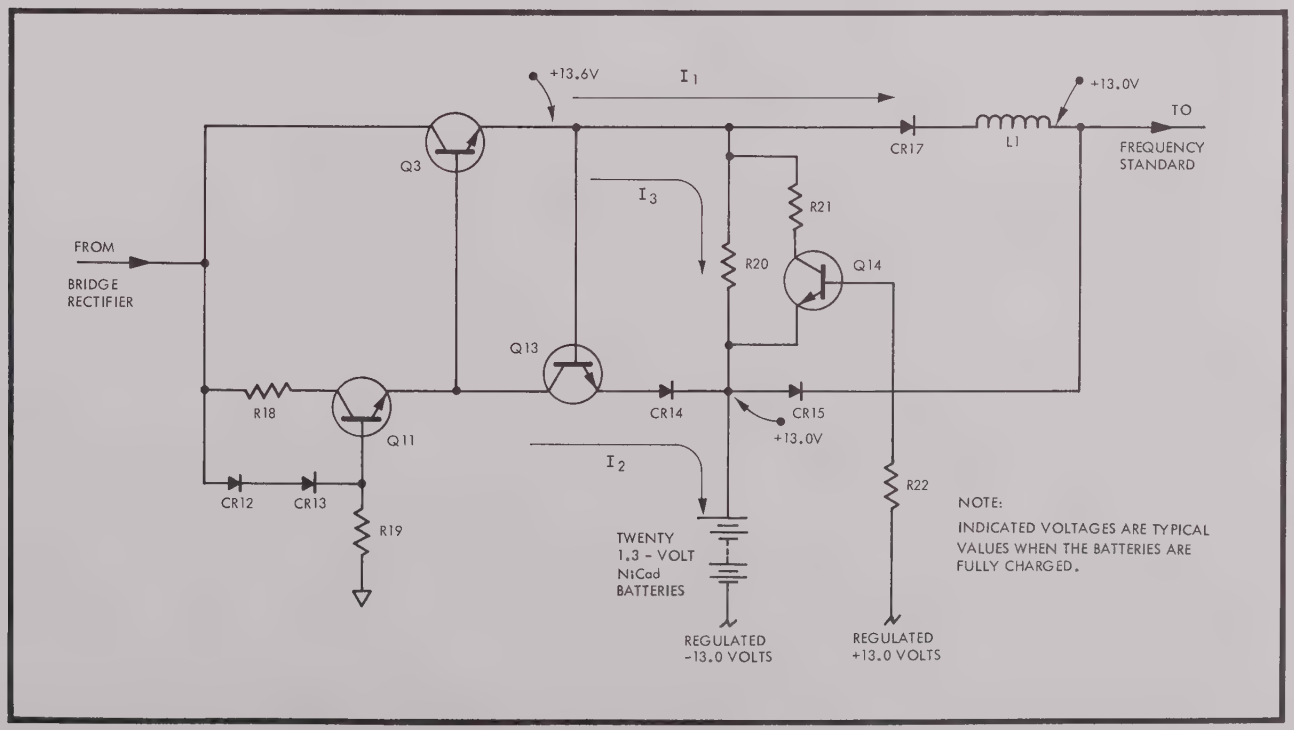


Figure 3-32. SIMPLIFIED SCHEMATIC DIAGRAM OF OPTIONAL BATTERY POWER SUPPLY FOR FREQUENCY STANDARD

cuits. Current path I_2 is a low-charging-rate current to maintain the batteries at full charge while the instrument is operated from the power line source. And current path I_3 is a relatively fast-charging-rate current path for restoring the batteries to their correct charge after operating the instrument on battery power. To aid in the explanation of this circuit, typical voltage values have been added to the diagram to indicate circuit operation when the batteries are fully charged. The rechargeable batteries used in this instrument have a nominal output voltage of 1.2 volts. However, when fully charged, their output voltage is higher than 1.3 volts. Because there are twenty batteries in series, the total voltage between the junction of CR14/CR15 and the -13-volt bus is 26 volts. Measured with respect to ground, this makes the voltage at the junction of the two diodes +13.0 volts. Assuming a +13 volt output to the frequency standard, the voltage at the emitter of Q3 (and also the base of Q13) is +13.6 volts. This voltage is not sufficient to forward bias both the base/emitter junction of Q13 and diode CR14. As a result there is essentially no current flow through Q13. However, as the battery terminal voltage drops, the emitter of Q13 also drops, forward biasing the transistor and permitting current flow through CR14 to charge the batteries. The amount of current is metered through constant-current source Q11 and is sufficient to maintain correct battery terminal voltages in the absence of a load. Notice that Q14 is not conducting because its base voltage is +13.0 volts and its emitter voltage is only slightly less than this. When the ac input power is removed from the instrument, diode CR15 begins to conduct, connecting the batteries to the frequency standard circuits, only. During the time the frequency standard is operated from the batteries, their output terminal voltages drop accordingly. As a result, when the ac power is restored, the voltage at the emitter of Q14 is something less than 13 volts ..... perhaps as low as 12 volts. This circuit condition forward biases Q14, providing additional charging current for the batteries. Then, as the batteries approach full charge, Q14 is once again back biased turning off the fast-charging-rate current. The batteries are maintained in their charged state by current through Q13.

SECTION IV

MAINTENANCE

4-1. INTRODUCTION

4-2. This section contains maintenance and service information for the 207 VLF Receiver/Comparitor. Maintenance primarily consists of periodic cleaning and calibration. If a problem arises, the information on corrective maintenance will help locate and correct the problem.

4-3. TEST EQUIPMENT

4-4. Figure 4-1 lists the recommended equipment and specifications required for calibration and corrective maintenance. If the recommended equipment is not available, other equipment which meets the required specifications may be used.

4-5. PERIODIC MAINTENANCE

4-6. Periodic maintenance consists primarily of occasional cleaning to remove dust, grease, and other types of contamination. Since the Model 207 is a completely enclosed unit, the need for occasional cleaning of the inside of the instrument is greatly reduced. Anhydrous denatured ethyl alcohol or a pressure can of Freon TF Degreaser (Miller-Stephenson Chemical Co., Inc.) may be used as a solvent when cleaning the instrument. A visual inspection should also be conducted to locate loose connections, mechanical defects, corrosion, and other possible sources of trouble.

4-7. CALIBRATION

4-8. The Model 207 should be calibrated as often as deemed necessary. However, it is recommended that the instrument be calibrated every six months under ordinary laboratory conditions. Calibration should be accomplished under typical laboratory conditions in a draft free area with an ambient temperature of 72.5 (±2.5) °F.

4-9. Calibration is usually done in the sequency given here. If desired, any module may be calibrated by using the given procedure after performing the preliminary calibration procedure. In this case, calibration will be successful as long as all other modules affecting the module being calibrated are within calibration limits.

4-10. All test points in the Model 207 are color coded according to their function. Black test points are connected to circuit common. Green test points are used for disabling circuits by shorting during maintenance and servicing. Yellow test points are used for measuring signal characteristics.

4-11. This procedure deals with component adjustments only and assumes that the modules are otherwise operating correctly. Only ten modules require adjustment (plus any optional Narrow Band RF Filters used); these modules and their manufacturing part number in the order of alignment are:

a. Power Supply, 207-1-406.

b. Phase Shifter, 207-1-403.

c. Divider, 207-1-402.

d. Phase Detector 207-1-401.

e. Readout, 207-1-404 (207-3-404 in Models 207-3, 207-5, and 207-5B).

EQUIPMENT NOMENCLATURE	SPECIFICATIONS REQUIRED	RECOMMENDED EQUIPMENT
Frequency Standard	Frequency: 100 kHz or 1 MHz Stability: $\pm 2 \times 10^{-9}$/24 hours Accuracy: $\pm 1 \times 10^{-7}$ Output Level: 1 volt rms	Motorola Model S1054AL Frequency Standard
Oscilloscope	Time Base: 1 sec to 0.1 usec Vertical Sensitivity: 0.05v/cm to 20v/cm Input Impedance: 10 MΩ, 10 pf	Tektronix Model 541A with Type L Plug In Unit and Type P6006 10:1 Passive Probe
Frequency Counter	Range: 100 Hz to 1 MHz	Systron-Donner Model 1033
Signal Generator	Frequency: 8 kHz to 60 kHz Stability: $\pm 2 \times 10^{-9}$ Accuracy: $\pm 1 \times 10^{-7}$ Output Level: 1 volt rms	Fluke Model 302 Frequency Synthesizer
Attenuator	Attenuation: 0 to 130 db in 1 db steps Frequency: 8 kHz to 60 kHz Accuracy: ±3 db Impedance: 50 ohms	Hewlett Packard Model 355C and 355D
RMS Voltmeter	Voltage Range: 10 mv to 1 volt Frequency: 60 Hz to 60 kHz	Fluke Model 910A True RMS Voltmeter
VTVM	Range: 0 to 26 vdc Accuracy: ±3% DC Input Impedance: 10 MΩ, 5 pf	RCA Voltohmyst
Model 207-1-445 Accessory Kit a. One 15 pin card riser b. One 22 pin card riser c. Two card pullers d. Two tuning tools e. Two shorting leads 50 ohm coaxial cables (such as RG58A/U) with BNC connectors. Coaxial tees with BNC connectors.		

Figure 4-1. TEST EQUIPMENT REQUIREMENTS

f. Preset Counter, 207-1-424 (207-1-414 for serial numbers 112 through 224).

g. Voltage Control Oscillator, 207-1-408.

h. Broadband RF, 207-1-417.

i. 51.1 kHz Mixer, 207-1-416.

j. 1.1 kHz IF Amplifier, 207-1-405.

4-12. PRELIMINARY CALIBRATION PROCEDURE

a. Connect all equipment as shown in Figure 4-2. The recommended equipment and specifications for calibration are shown in Figure 4-1.

b. Turn on all test equipment and let it warm up to operating temperature.

c. Remove top cover of instrument and top cover of rf encloser.

d. Make sure all modules are installed firmly into chassis connectors.

e. Leave ANTENNA input signal and 100 kHz - 1 MHz STD FREQ IN signal disconnected until instructed. Antenna input signal level is set up by adjusting Frequency Synthesizer output for 1 volt as indicated on RMS Voltmeter and then setting external attenuators and RF ATTENUATOR switch on 207 for total db below 1 volt desired.

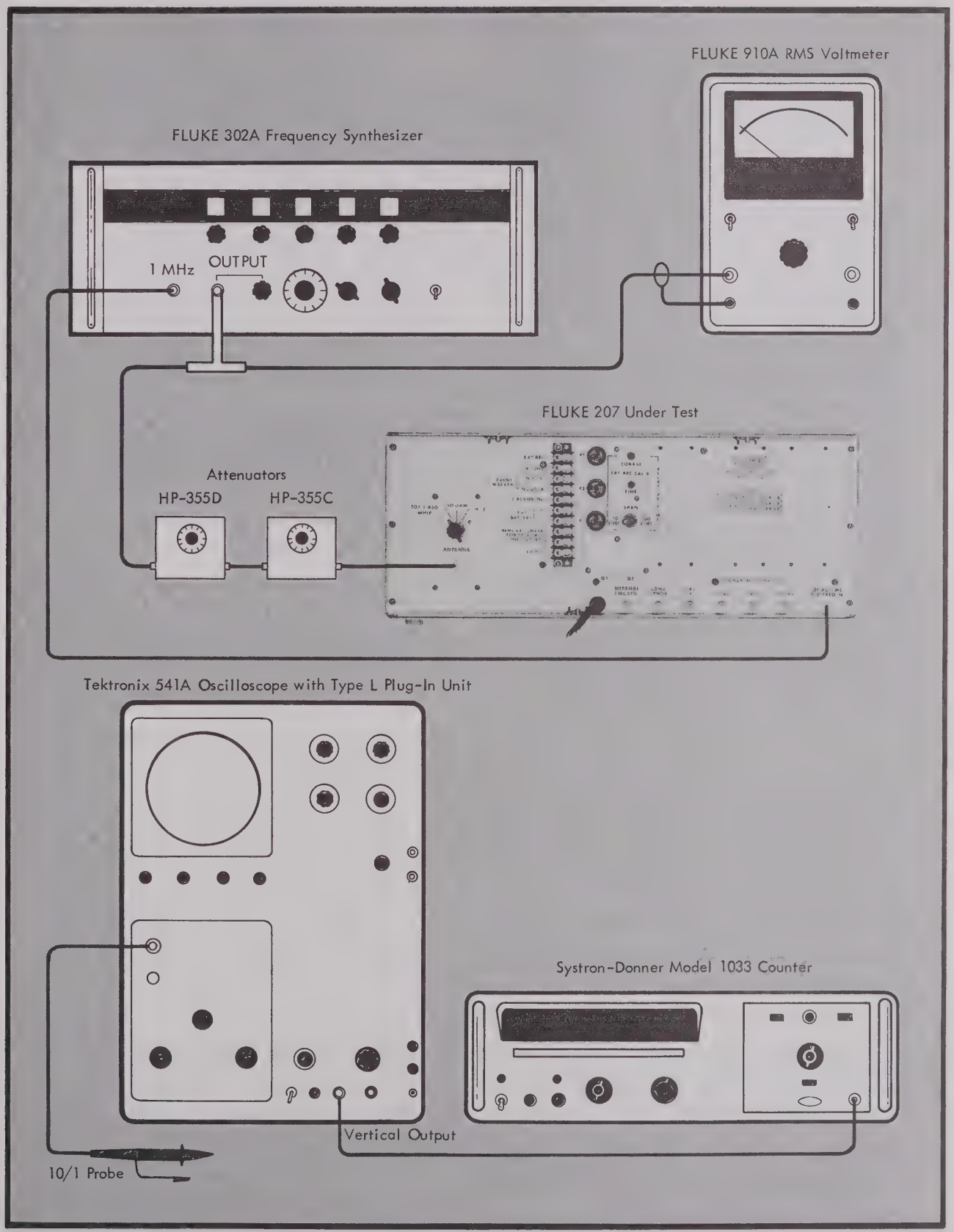


Figure 4-2. EQUIPMENT CONNECTIONS FOR CALIBRATION AND CORRECTIVE MAINTENANCE

4-13. POWER SUPPLY CALIBRATION, 207-1-406

4-14. All adjustments for Power Supply Module calibration may be located with the aid of Figure 4-3.

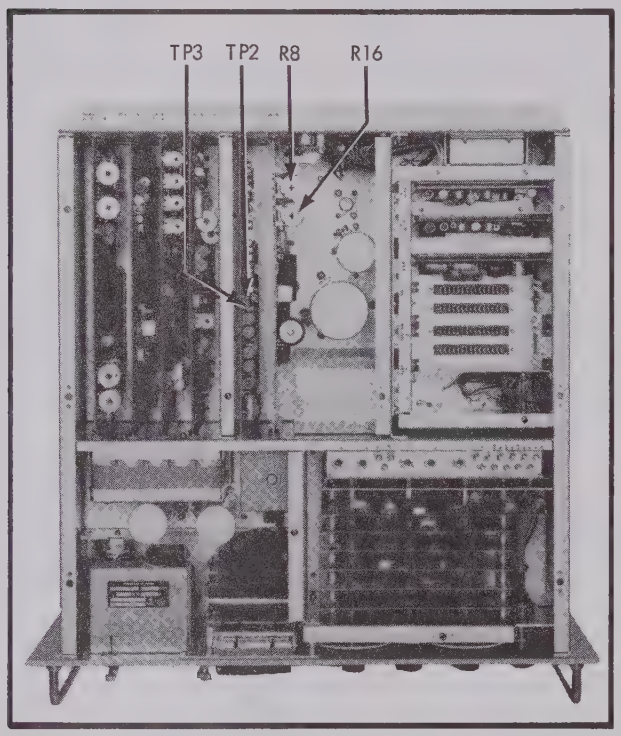


Figure 4-3. LOCATION OF IF AMPLIFIER TEST POINTS USED THROUGHOUT CALIBRATION AND POWER SUPPLY ADJUSTMENTS

a. Set POWER switch to on and METER FUNCTION switch to +PWR.

b. Adjust R16 (+13V ADJ) until meter needle is in line with black POWER alignment mark.

c. Set METER FUNCTION switch to -PWR.

d. Adjust R8 (-13V ADJ) until meter needle is in line with black POWER alignment mark.

4-15. PHASE SHIFTER CALIBRATION, 207-1-403

4-16. All adjustments and test points used for Phase Shifter Module calibration may be located with the aid of Figure 4-4. Use the Mullard adjustment tool for adjusting L1, L2, T1 and T2.

a. Set POWER switch to off, place 22 pin riser card between Model 207 and Phase Shifter Module, and set POWER switch to on.

b. Apply 100 kHz standard frequency to 100 KHz - 1 MHz STD FREQ IN connector.

c. Connect oscilloscope ground to TP12.

d. With oscilloscope probe at TP2, adjust R15 (DIV ADJ) for a negative pulse approximately 0.5 microseconds wide having a period of 10 microseconds (Figure 4-5). Most stable operation of the n to 1 divider is obtained when variable droop in falling edge of pulse is made to just start down (Figure 4-6).

e. Short TP5 to TP11 and adjust L1 for maximum amplitude of 900 kHz waveform with oscilloscope probe at TP4. In adjusting this tuned circuit, the range of the controls allows peaks to occure at other than desired frequency. Make sure that counter indicates 900 kHz when oscilloscope indicates a maximum. Remove shorting jumper.

f. Adjust T1 for minimum amplitude of 900 kHz waveform with oscilloscope probe at TP4.

g. Short TP7 to TP11 and adjust L2 for maximum amplitude of 1 MHz waveform with oscilloscope probe at TP6. Make sure counter indicates 1 MHz when oscilloscope indicates a maximum. Remove shorting jumper.

h. Adjust T2 for minimum amplitude of 1 MHz waveform with oscilloscope probe at TP6.

i. Adjust R15 slightly for maximum amplitude of 1 MHz waveform with oscilloscope probe at TP6.

j. Set FREQUENCY/KHz dials to 00.0 and complete each line of Figure 4-7.

Note!

With the FREQUENCY/KHz dials set to 00.0, the ACCUMULATIVE ERROR counter will count either up or down at a speed determined by the timing clock on the Phase shifter module. The speed of the timing clock is determined by four rc circuits any one of which may be selected with the TRACKING RATE switch. The time constant of these rc circuits, and thus the tracking rate, can be set accurately by adjusting the resistance of each rc circuit for the correct number of counts in a fixed period of time.

k. Disconnect 100 kHz standard frequency from 100 kHz - 1 MHz STD FREQ IN connector.

l. Set POWER switch to off, remove riser card, and plug Phase Shifter Module into Model 207 chassis.

4-17. DIVIDER CALIBRATION, 207-1-402

4-18. All adjustments and test points used for Divider Module Calibration may be located with the aid of Figure 4-8. Use Mullard adjustment tool for adjusting L1, L2, T1, T2 and T3.

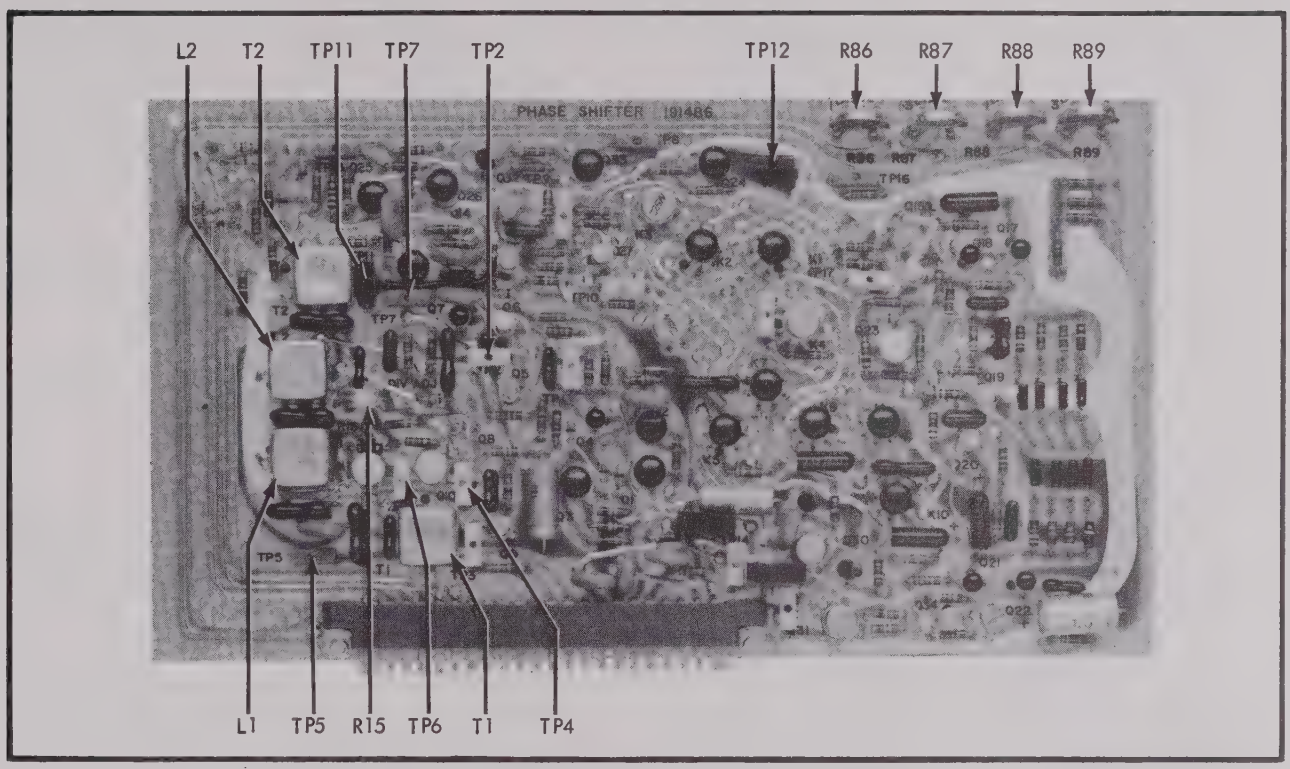


Figure 4-4. PHASE SHIFTER MODULE ADJUSTMENT AND TEST POINT LOCATIONS

a. Set POWER switch to off, place 22 pin riser card between Model 207 and Divider Module, and set POWER switch to on.

b. Connect oscilloscope ground to TP14.

c. Connect 1 MHz standard frequency to 100 kHz - 1 MHz STD FREQ IN connector.

d. Adjust T1 for maximum amplitude of 100 kHz waveform with oscilloscope probe at TP3.

e. Short TP5 to TP6 and adjust L1 for maximum amplitude of 1 MHz waveform with oscilloscope probe at TP4. Make sure counter indicates 1 MHz when oscilloscope indicates a maximum. Remove shorting jumper.

f. Adjust T2 for minimum amplitude of 1 MHz waveform with oscilloscope probe at TP4.

g. Short TP11 to TP6 and adjust L2 for maximum amplitude of 11 kHz waveform with oscilloscope probe at TP10. Make sure counter indicates 11 kHz when oscilloscope indicates a maximum. Remove shorting jumper.

h. Adjust T3 for a minimum amplitude of 11 kHz waveform with oscilloscope probe at TP10.

i. Set POWER switch to off, remove riser card, and plug Divider Module into Model 207 chassis.

4-19. PHASE DETECTOR CALIBRATION, 207-1-401

4-20. All adjustments and test points used for Phase Detector Module calibration (except TP2 and TP3 on IF Amplifier Module) may be located with the aid of Figure 4-9.

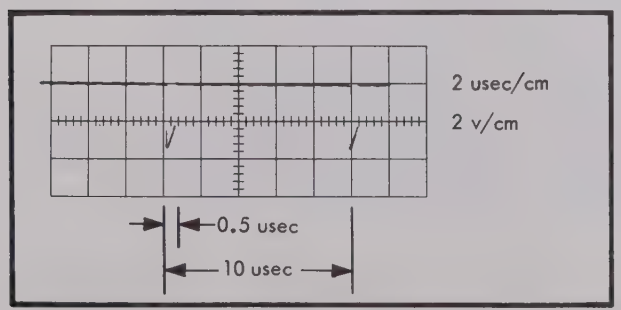


Figure 4-5. WAVEFORM AT TP2

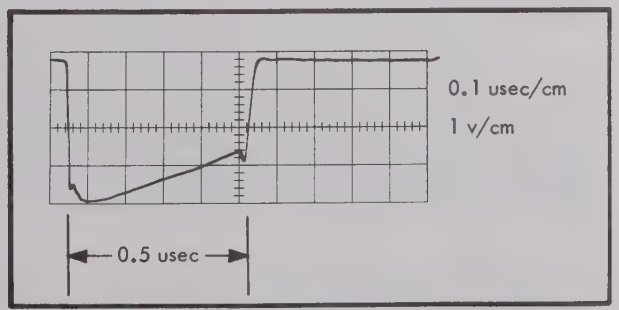


Figure 4-6. WAVESHAPE OF PULSE AT TP2

Set TRACKING RATE switch to	Adjust	For the following counts on ACCUMULATIVE ERROR counter in 10 seconds
1×10^{-6}	R86	100 counts (10.0 usec)
3×10^{-7}	R87	30 counts (3.0 usec)
1×10^{-7}	R88	10 counts (1.0 usec)
3×10^{-8}	R89	3 counts (0.3 usec)

Figure 4-7. TRACKING RATE ADJUSTMENTS

a. Set POWER switch to off, place 22 pin riser card between Model 207 and Phase Detector Module, and set POWER switch to on.

b. Set METER FUNCTION switch to SIG PD and FREQUENCY/KHz dials to 00.0, short TP13 to TP11 and TP14 to TP12, and adjust R92 (SIG PD BAL) until meter needle is in line with black ALIGNment mark. When balancing signal phase detector, allow sufficient time (about 6 minutes) for meter needle to come to a stop. This is due to the long time constant of the signal phase detector. Remove shorting jumpers.

c. Short TP2 to TP3 on IF Amplifier Module (see Figure 4-3), set FREQUENCY/KHz dials away from 00.0, and adjust R71 (SIG PD BAL) until meter needle is in line with black ALIGNment mark. Remove shorting jumper.

d. Set METER FUNCTION switch to SERVO PD, TRACKING RATE switch to 1×10^{-6}, FREQUENCY/KHz dials to 00.0, short TP9 to TP11 and TP10 to TP12, and adjust R90 (SERVO PD BAL) until meter needle is in line with black ALIGNment mark. Remove shorting jumpers.

e. Short TP2 to TP3 on IF Amplifier Module, set FREQUENCY/KHz dials away from 00.0, and adjust R8 (SERVO PD BAL) until meter needle is in line with black ALIGNment mark. Remove shorting jumper.

f. Set POWER switch to off, remove riser card, and plug Phase Detector into Model 207 chassis.

4-21. READOUT CALIBRATION, 207-1-404 or 207-3-404

4-22. All adjustments and test points used for Readout Module calibration may be located with the aid of Figure 4-10. Note that the 207-3-404 Readout Module used in Models 207-3, 207-5 and 207-5B is the same as the 207-1-404 Readout Module except for the additional circuits used for the comparison input.

a. Set POWER switch to off, place 22 pin riser card between Model 207 and Readout Module, and set POWER switch to on.

b. Remove plug on front panel of recorder, press RECORDER CAL switch to 0, adjust meter zero control for 0 on recorder, and replace plug.

c. Press RECORDER CAL switch to 100 and adjust R43 (RECORDER CALIB COARSE ADJ) for approximately 100 on recorder; fine adjust to 100 with R47 (FINE ADJ).

d. For instruments using Readout Module 207-3-404, proceed with comparison input calibration given in steps e through g. For instruments using Readout Module 207-1-404, proceed in step h.

e. Connect 100 kHz standard frequency to COMPARISON INPUT connector on front panel.

f. Connect oscilloscope ground to TP7.

g. With oscilloscope probe at TP2, adjust R14 for a negative pulse approximately 0.5 microseconds wide having a period of 10 microseconds (Figure 4-5). Most stable operation of the n to 1 divider is obtained when the variable droop in falling edge of pulse is made to just start down (Figure 4-6).

h. Set POWER switch to off, disconnect standard frequency from COMPARISON INPUT connector, remove riser card, and plug Readout Module into Model 207 chassis.

4-23. PRESET COUNTER CALIBRATION, 207-1-414 (serial numbers 112 to 224)

4-24. All adjustments and test points used for Preset Counter Calibration (s/n 112 to 224) may be located with the aid of Figure 4-11.

a. Connect oscilloscope ground to TP4.

b. Adjust R3 (100 MICROSECOND ADJUST) for a 100 microsecond pulse duration with oscilloscope probe at TP3.

c. Short TP1 to TP2, set METER FUNCTION switch to SYNTHesizer, and adjust R18 (METER BALANCE) until meter needle lines up with black ALIGNment mark. Remove shorting jumper.

4-25. PRESET COUNTER CALIBRATION, 207-1-424 (serial numbers 225 and on)

4-26. All adjustments and test points used for Preset Counter Calibration (s/n 225 and on) may be located with the aid of Figure 4-12.

a. Connect oscilloscope ground to TP6.

b. With oscilloscope probe at TP2, trigger on negative going edge, and adjust R8 (900 MICROSECOND ADJUST) for a 100 microsecond pulse duration. Note that R8 adjusts the period of a 900 microsecond one shot which is cycling every 1000 microseconds.

c. Short TP4 to TP5, set METER FUNCTION switch to SYNTHesizer, and adjust R22 (METER BALANCE) until meter needle lines up with black ALIGNment mark. Remove shorting jumper.

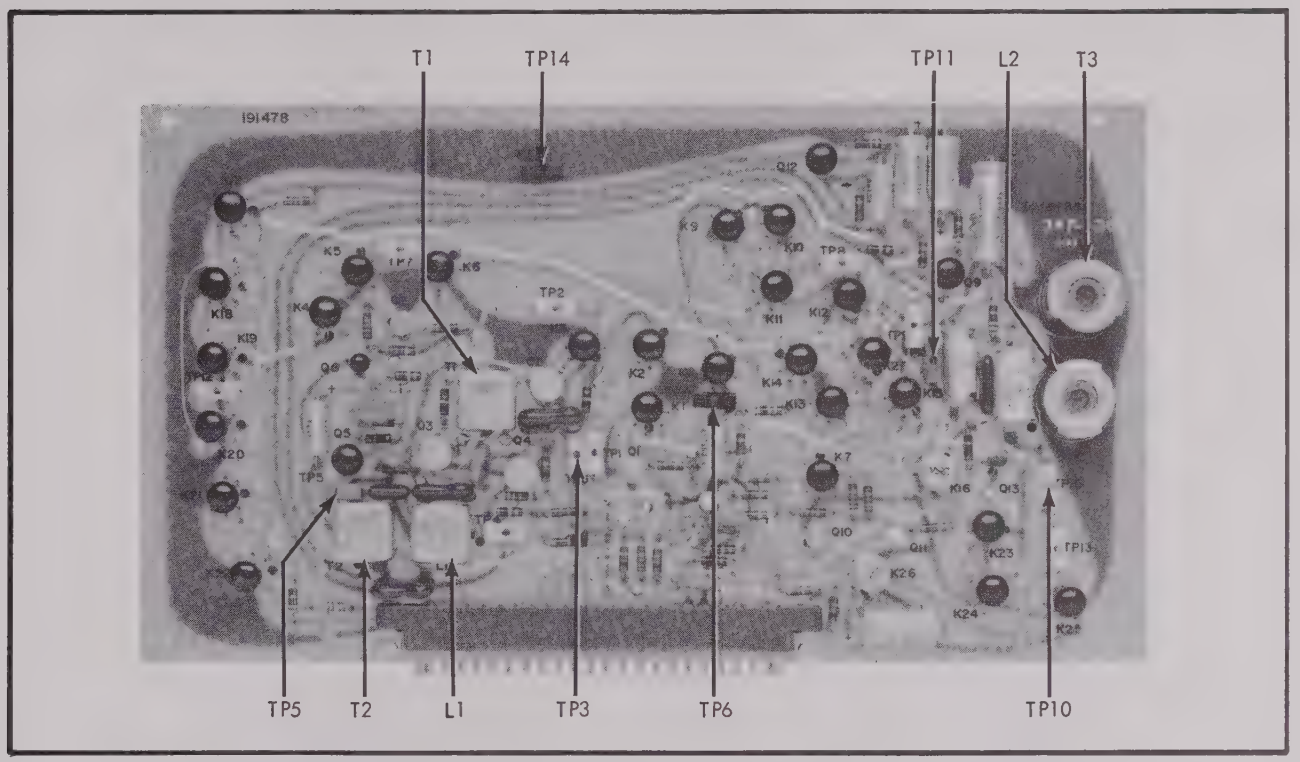


Figure 4-8. DIVIDER MODULE ADJUSTMENT AND TEST POINT LOCATIONS

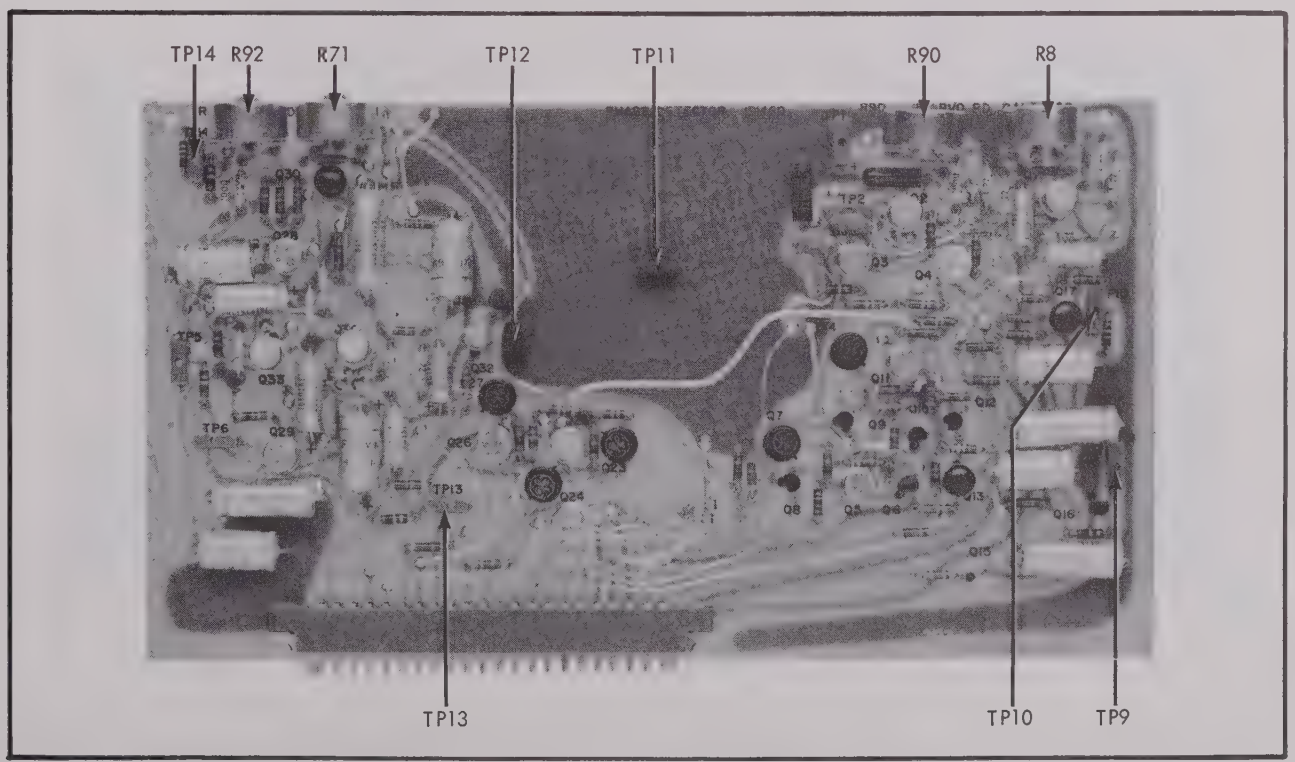


Figure 4-9. PHASE DETECTOR MODULE ADJUSTMENT AND TEST POINT LOCATIONS

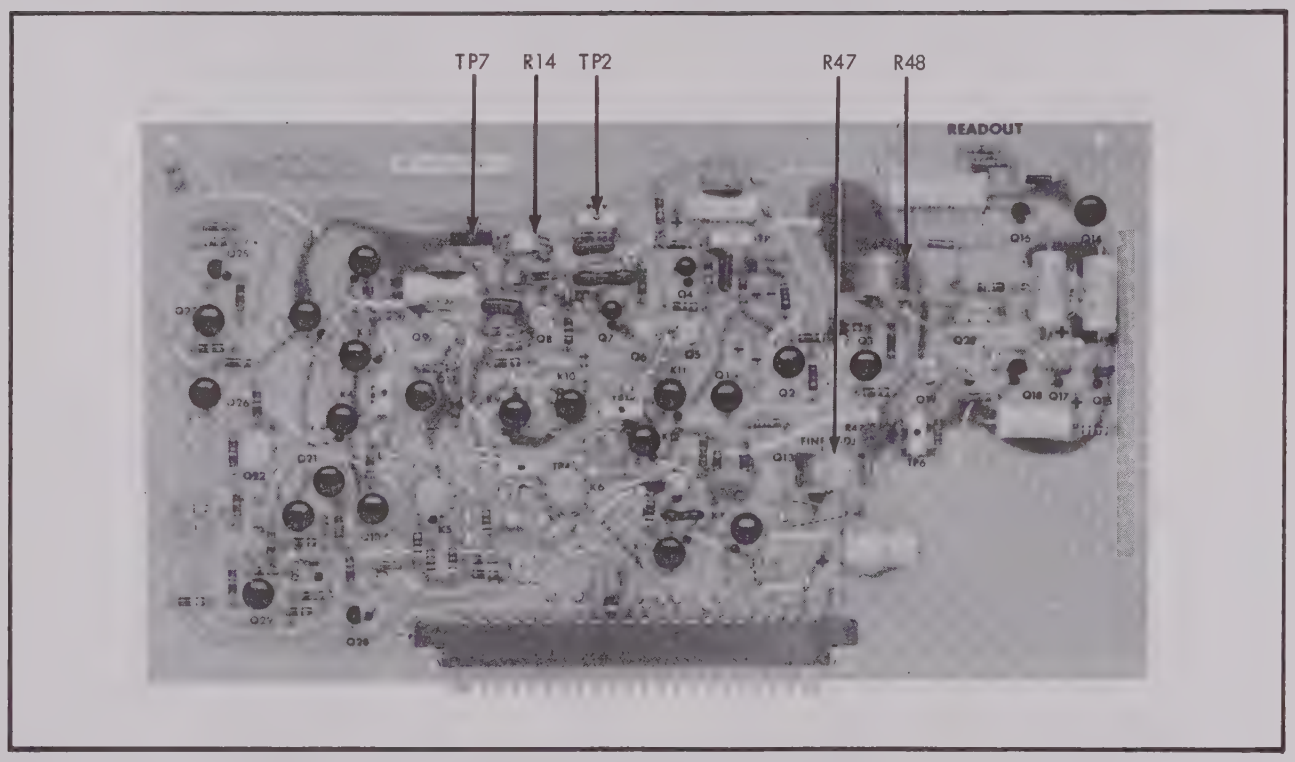


Figure 4-10. READOUT MODULE ADJUSTMENT AND TEST POINT LOCATIONS

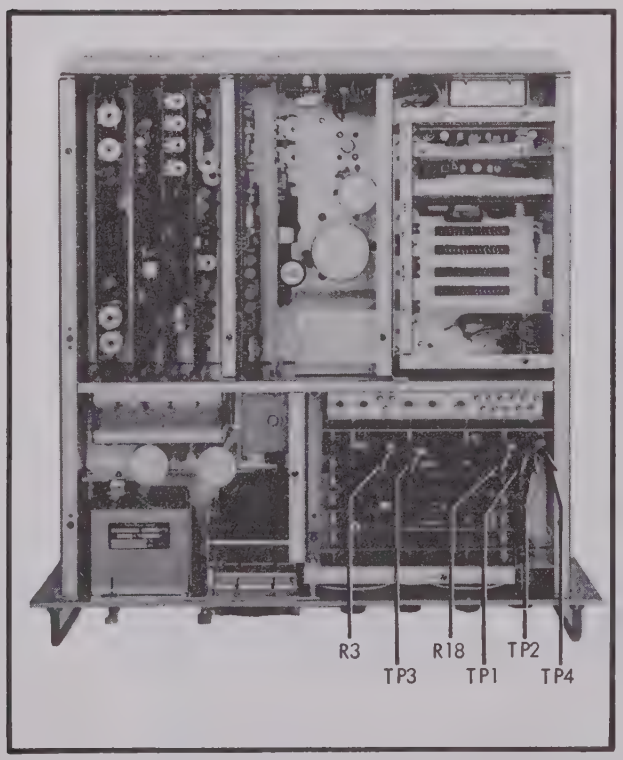


Figure 4-11. PRESET COUNTER (S/N 112 to 224) ADJUSTMENT AND TEST POINT LOCATIONS

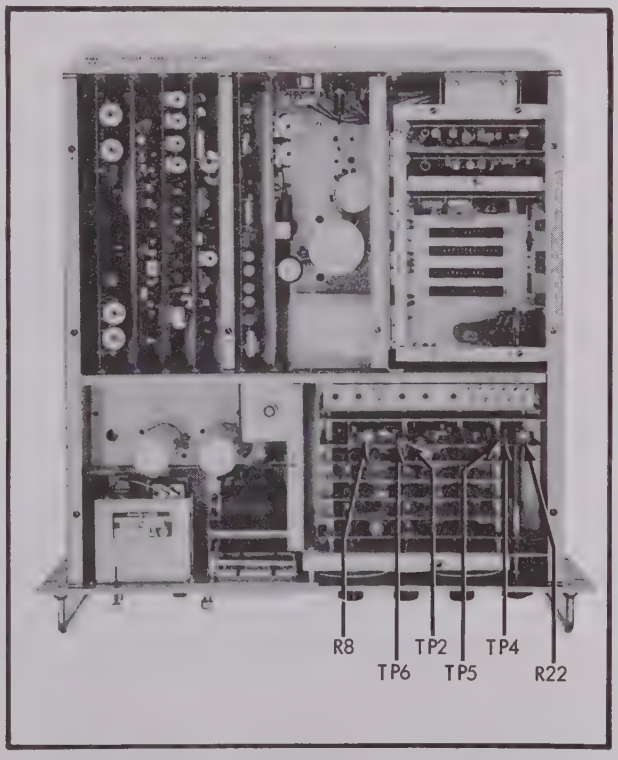


Figure 4-12. PRESET COUNTER (S/N 225 and on) ADJUSTMENT AND TEST POINT LOCATIONS

4-27. VOLTAGE CONTROLLED OSCILLATOR CALIBRATION, 207-1-408

4-28. All adjustment used for Voltage Controlled Oscillator calibration may be located with the aid of Figure 4-13. Use JFD adjustment tool for adjusting T1 through T5.

a. Set METER FUNCTION switch to SYNTHesizer.

b. Align Voltage Controlled Oscillator by performing each line of Figure 4-14. When adjusting for meter center, line up meter needle with black ALIGNment mark. Output of synthesizer may be checked by connecting a frequency counter to CONV SYNTH output connector on rear of instrument.

4-29. BROADBAND RF AMPLIFIER CALIBRATION, 207-1-417

4-30. All adjustments and test points used for Broadband RF Amplifier Module calibration (except TP2 on IF Amplifier Module) may be located with the aid of Figure 4-15. Use Mullard adjustment tool for adjusting L4, L5, T1 and T2.

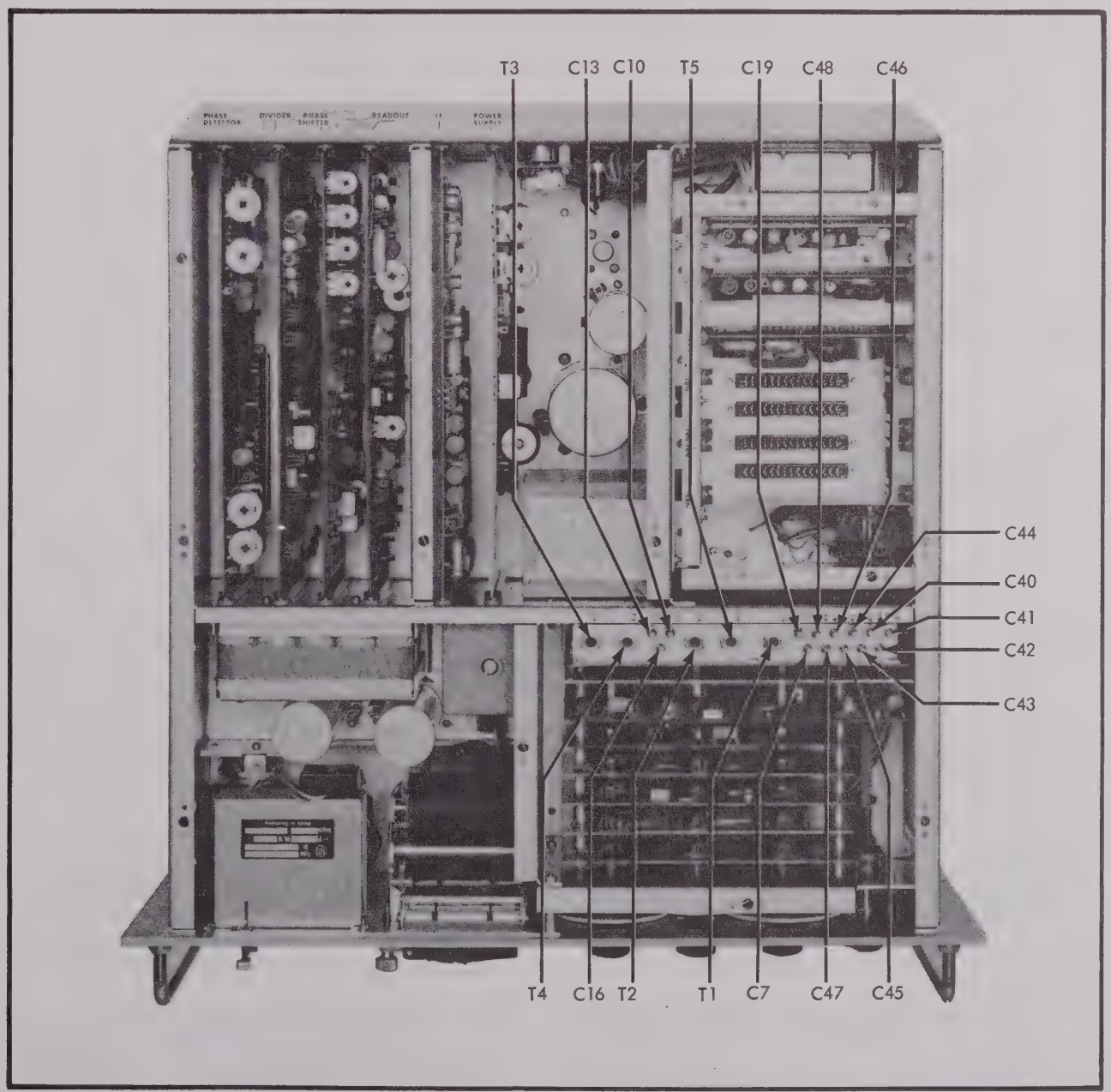


Figure 4-13. VOLTAGE CONTROLLED OSCILLATOR ADJUSTMENT LOCATIONS

Set FREQUENCY/KHz dials to	Adjust the following components for the indicated condition	Frequency at CONV SYNTH output connector should be
09.5	C7 to center of its range T1 for meter center C7 fine tune for center	60.6 kHz
19.5	C10 to center of its range T2 for meter center C10 fine tune for center	70.6 kHz
29.5	C13 to center of its range T3 for meter center C13 fine tune for center	80.6 kHz
39.5	C16 to center of its range T4 for meter center C16 fine tune for center	90.6 kHz
60.0	C19 to center of its range T5 for meter center C19 fine tune for center	111.1 kHz
18.5	C48 for meter center	69.6 kHz
17.5	C47 for meter center	68.6 kHz
16.5	C46 for meter center	67.6 kHz
15.5	C45 for meter center	66.6 kHz
14.5	C44 for meter center	65.6 kHz
13.5	C43 for meter center	64.6 kHz
12.5	C42 for meter center	63.6 kHz
11.5	C41 for meter center	62.6 kHz
10.5	C40 for meter center	61.6 kHz

Figure 4-14. ALIGNMENT OF VOLTAGE CONTROLLED OSCILLATOR

a. Set POWER switch to off, place 15 pin riser card between Model 207 and Broadband RF Amplifier Module, and set POWER switch to on.

b. Connect oscilloscope ground to a black test point.

c. Set ANTENNA switch on rear of instrument to 50 OHM and set FREQUENCY/KHz dials to 60.0.

d. Apply 1 millivolt (-60 db relative to 1 volt rms) at 60.0 kHz to ANTENNA input connector on rear of instrument.

e. Short TP3 to TP1 and adjust T1 for maximum amplitude of 60.0 kHz waveform with oscilloscope probe at TP2. Remove shorting jumper.

f. Adjust T2 for minimum amplitude of 60.0 kHz waveform with oscilloscope probe at TP2.

g. Apply 1 volt at 51.1 kHz to ANTENNA input connector and adjust L4 and L5 for minimum signal with oscilloscope probe at TP2 of IF Amplifier Module, 207-1-405 (see Figure 4-3). When adjustment is completed, signal level should be less than 50 millivolts peak-to-peak.

h. Set POWER switch to off, disconnect antenna input signal, remove riser card, and plug Broadband RF Amplifier Module into Model 207 chassis.

4-31. 51.1 kHz MIXER CALIBRATION, 207-1-416

4-32. All adjustments and test points used for 51.1 kHz Mixer Module calibration may be located with the aid of Figure 4-16. Use Mullard adjustment tool for adjusting T1 and T2.

a. Set POWER switch to off, place 15 pin riser card between Model 207 and 51.1 kHz Mixer Module, and set POWER switch to on.

b. Connect oscilloscope ground to a black test point.

c. Set ANTENNA switch on rear of instrument to 50 OHM and set FREQUENCY/KHz dials to 20.0.

d. Apply 1 millivolt (-60 db relative to 1 volt rms) at 20.0 kHz to ANTENNA input connector on rear of instrument.

e. Short TP3 to TP4 and adjust T1 for maximum amplitude of 51.1 kHz waveform with oscilloscope probe at TP2. Remove shorting jumper.

f. Adjust T2 for minimum amplitude of 51.1 kHz waveform with oscilloscope probe at TP2.

g. Set POWER switch to off, disconnect antenna input signal, remove riser card, and plug 51.1 kHz Mixer Module into Model 207 chassis.

4-33. 1.1 kHz IF AMPLIFIER CALIBRATION, 207-1-405

4-34. All adjustments and test points used for 1.1 kHz IF Amplifier Module calibration may be located with the aid of Figure 4-17. Use Mullard adjustment tool for adjusting L1 through L4.

a. Set POWER switch to off, place 22 pin riser card between Model 207 and 1.1 kHz IF Amplifier Module, and set POWER switch to on.

b. Connect oscilloscope ground to a black test point.

c. Set ANTENNA switch on rear of instrument to 50 OHM and set FREQUENCY/KHz dials to 20.0.

d. Apply 32 microvolts (-90 db relative to 1 volt rms) to 20.0 kHz to ANTENNA input connector on rear of instrument.

e. Short TP4 to TP1 and adjust L2 for maximum amplitude of 1.1 kHz waveform with oscilloscope probe at TP5. Remove shorting jumper.

f. Adjust L4 for minimum amplitude of 1.1 kHz waveform with oscilloscope probe at TP5.

g. Short TP7 to TP1 and adjust L1 for maximum amplitude of 1.1 kHz waveform with oscilloscope probe at TP6. Remove shorting jumper.

h. Adjust L3 for minimum amplitude of 1.1 kHz waveform with oscilloscope probe at TP6.

i. Set POWER switch to off, disconnect antenna input signal, remove riser card, and plug 1.1 kHz IF Amplifier Module into Model 207 chassis.

4-35. NARROW BAND RF FILTER CALIBRATION, 207-422XXX

4-36. Narrow band rf filter modules are available for any channel frequency within the range of the Model 207. The last three digits of the module number indicate the channel frequency of the filter. For example, Module 207-422600 is a filter module for 60.0 kHz. Four filter modules may be pluged into numbered slots in the rf encloser of the instrument. The desired filter or broadband operation may be selected with the front panel RF FILTER switch.

a. Set POWER switch to off, place 15 pin card riser between Model 207 and Narrow Band RF Filter Module, and set POWER switch to on.

b. Set ANTENNA switch on rear of instrument to 50 OHM, RF ATTENUATOR switch to 40 DECIBELS, and RF FILTER switch to appropriate filter slot number.

c. Apply 1 volt (within 1 part in 10^4) at the channel frequency of the filter to ANTENNA input connector on rear of instrument.

d. Connect oscilloscope ground to a black test point.

e. Short TP3 to TP1 and adjust T2 for maximum amplitude of signal with oscilloscope probe at TP2. Remove shorting jumpers.

f. Adjust T1 for minimum amplitude of signal with oscilloscope probe at TP2.

g. Set POWER switch to off, disconnect antenna input signal, remove riser card, and plug Narrow Band RF Filter into Model 207 rf encloser.

4-37. CORRECTIVE MAINTENANCE

4-38. Corrective Maintenance consists of the location and correction of troubles should the Model 207 fail to function properly. Thus, for the most part, corrective maintenance is concerned with troubleshooting. Troubleshooting begins by first isolating troubles to a particular module. The troubles are then further isolated to a particular faulty component or group of components. In addition to troubleshooting, information is included here on soldering techniques and repair of the Frequency Synthesizer. All equipment required for maintaining the instrument is listed in Figure 4-1.

4-39. ISOLATING TROUBLES TO A MODULE

4-40. Three possible methods (module substitution, front panel trouble isolating checks and module input-output measurements) are presented here for isolating troubles to a particular module in the instrument. Be-

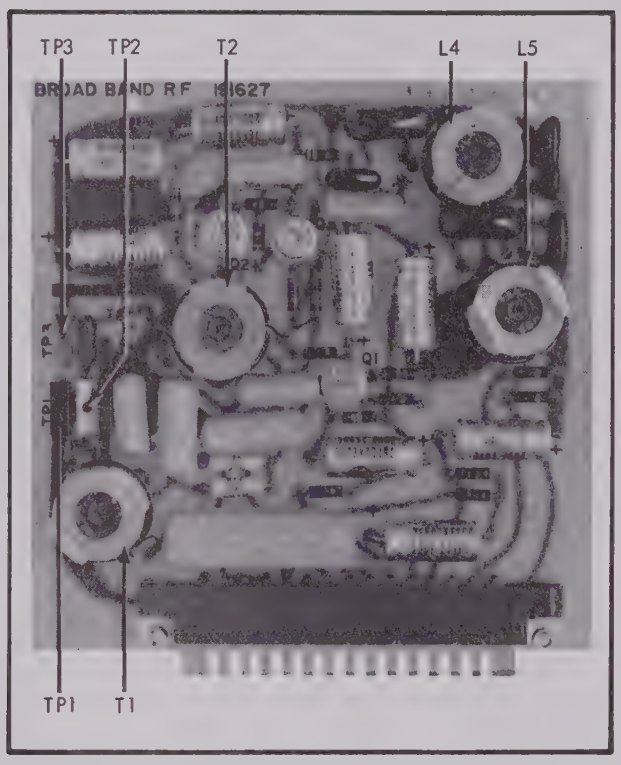


Figure 4-15. BROADBAND RF AMPLIFIER ADJUSTMENT AND TEST POINT LOCATIONS

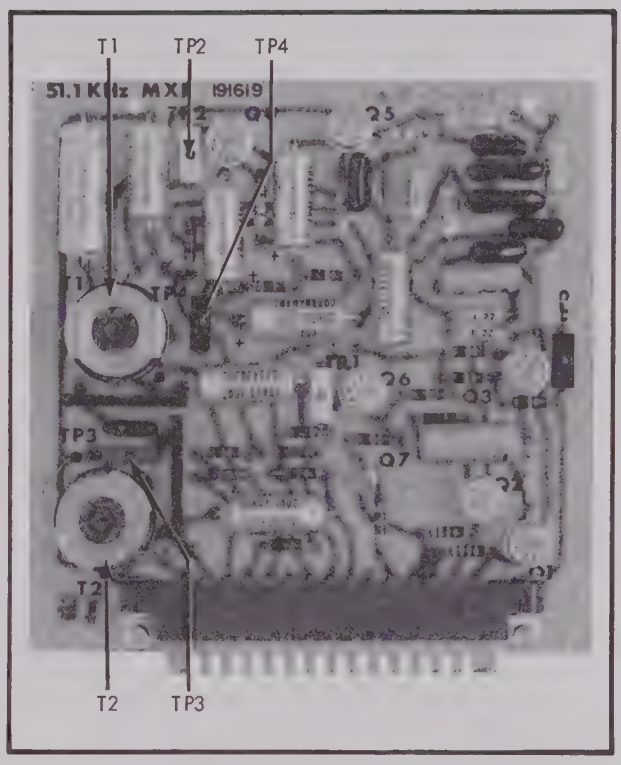


Figure 4-16. 51.1 kHz MIXER ADJUSTMENT AND TEST POINT LOCATIONS

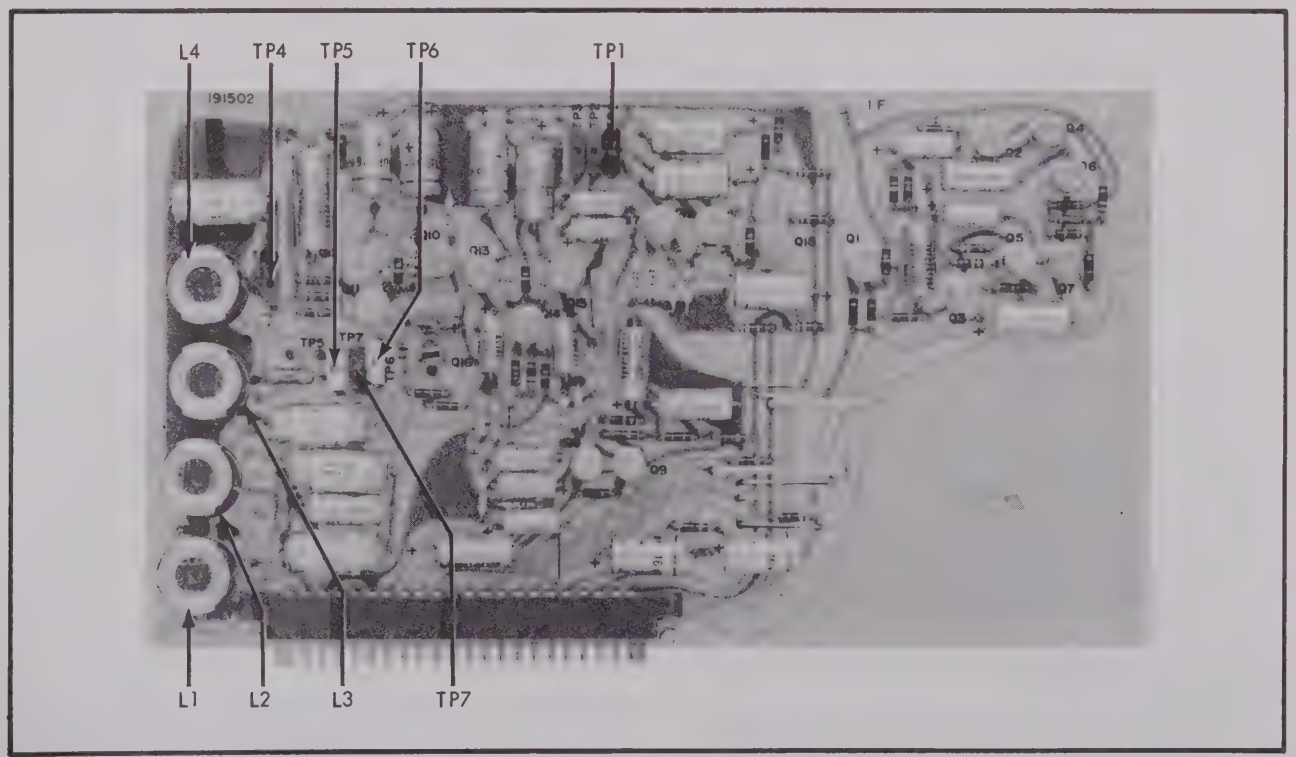


Figure 4-17. 1.1 kHz IF AMPLIFIER ADJUSTMENT AND TEST POINT LOCATIONS

fore using any of these methods, make sure that all inputs to the Model 207 are within tolerance. In particular, make sure the frequency standard used is within 1 part in 10^6 of the correct frequency.

4-41. A valuable technique used with the troubleshooting information given here is the setting up of an artificial if signal within the instrument. This is done by setting the FREQUENCY/KHz dials to 00.0 with a frequency standard connected to the 100 KHz - 1 MHz STD FREQ IN connector. With the FREQUENCY/KHz dials set to 00.0, the mixing frequency fed to the 51.1 kHz Mixer Module is 51.1 kHz + $F_{received}$ = 51.1 kHz. Thus a strong signal is set up in the receiver circuits. However, the instrument can not track this signal because every time the reference signal is phase shifted, the artificial antenna signal is also phase shifted. As a result, one output of the normally balanced servo phase detector will settle either high or low with respect to the other output. One output of the signal phase detector will also settle either high or low with respect to the other output. Combining these conditions results in the four possible ways shown in Figure 4-18, that the instrument will settle to when the FREQUENCY/KHz dials are set to 00.0. The instrument may be changed from one condition to another in a random manner by setting the POWER switch to off and then to on.

ACCUMULATIVE ERROR COUNTER	SERVO PD METER INDICATION	SIG PD METER INDICATION	RF SIG METER INDICATION	NO LOCK LAMP
COUNTING UP				OFF
COUNTING UP				ON
COUNTING DOWN				OFF
COUNTING DOWN				ON

Figure 4-18. POSSIBLE SERVO LOOP CONDITIONS WITH FREQUENCY/KHz DIALS SET TO 00.0

4-42. MODULE SUBSTITUTION. Troubles may be isolated to a particular module by replacing a module suspected of being faulty with a module that is known to be operating correctly. When the faulty module is located, the trouble may be further isolated to the components responsible or the module may be shipped to the Fluke factory or local Fluke representative for repair.

4-43. FRONT PANEL TROUBLE ISOLATING CHECKS. Troubles may be isolated to a particular module by using the front panel trouble isolating checks given in Figure 4-19. These checks may be performed from the outside of the instrument with the aid of only a paper clip or a short piece of wire.

4-44. MODULE INPUT-OUTPUT MEASUREMENTS. Troubles may be isolated to a particular module by making input and output waveform and voltage measurements as specified in the troubleshooting chart of Figure 4-21. Module connectors may be located with the aid of Figure 4-20.

4-45. TROUBLESHOOTING MODULE CIRCUITS

4-46. The procedures given in the following paragraphs will help localize problems on particular modules. Additional measurements may then be made with the aid of the information given on the schematic diagrams. These measurements will, in most cases, allow isolation of a trouble to the faulty component. Frequent reference to Section III, Theory of Operation, for information on the operation of circuits in a module will help locate the cause of any abnormal condition.

4-47. PHASE DETECTOR TROUBLESHOOTING. The information given on the schematic diagram should allow isolation of a trouble to the faulty component. In addition, the following characteristics of the Phase Detector will provide further insight into the functioning of the circuit.

a. The clock voltage at P1-2 is at its minimum value when the servo phase detector is balanced. It reaches its maximum value when the servo phase detector is unbalanced by approximately a 0.4 microsecond or greater phase difference between the received signal and the reference frequency that is phase shifted from the frequency standard.

b. The NO SIGNAL lamp is turned off when either the servo phase detector or the signal phase detector is not balanced. When the servo phase detector is unbalanced, the NO SIGNAL lamp is turned off due to either Q11 - Q14 or Q5 - Q7 being in their conducting state. When the signal phase detector is unbalanced in the direction opposite its normally phase locked state, the NO SIGNAL lamp is turned off due to Q27 being in its conducting state. When the signal phase detector is unbalanced in its normally phase locked state, the NO SIGNAL lamp is turned off due to Q25 on the Readout Module being in its conducting state.

4-48. DIVIDER TROUBLESHOOTING. The waveforms on the schematic diagram should allow isolation of a trouble to the faulty component or to a group of components. Difficulty may be encountered when trying to troubleshoot stages containing JK Flip Flops ICs. This is particularly true when the JK Flip Flop is in a feedback circuit such as the divide by five circuit. The fact that a JK Flip Flop acts as a divide by two circuit with respect to the trigger signal when the set (S) and clear (C) terminals are grounded provides a good troubleshooting technique. When the set or clear terminal is fed from the output of another IC, the set or clear terminal may be grounded without damage to components. Thus, to troubleshoot the 100 kHz 5/1 circuit, ground the set terminal of K1 and check for 250 kHz at the output of K1. Then, ground the clear terminal of K2 and check for 250 kHz at the output of K2.

4-49. PHASE SHIFTER TROUBLESHOOTING. Troubles on the Phase Shifter Module may be quickly isolated to a stage or functionally related stages as follows:

a. Check TP14 and TP15 for waveforms shown on schematic diagram. If waveforms are available, the trouble is in ACCUMULATIVE ERROR counter.

STEP	PURPOSE OF CHECK	PROCEDURE	PROPER INDICATION	SOURCES OF IMPROPER INDICATION
a	To check +13 vdc and -13 vdc power supplies.	Disconnect antenna from ANTENNA connector and connect frequency standard to 100 kHz - 1 MHz STD FREQ IN connector. Set 207 switches as follows: RF FILTER — BROADBAND RF ATTENUATOR — 0 DECIBELS TRACKING RATE — 1×10^{-6} ACCUMULATOR — OFF POWER — on METER FUNCTION — +PWR and then -PWR	Meter should indicate within green POWER band when power supplies are within tolerance.	Calibrate or troubleshoot Power Supply.
b	To check synthesizer alignment.	Set METER FUNCTION switch to SYNTH, FREQUENCY/KHz dials to 69.0 and then change to 60.0.	Meter should indicate far above green ALIGN band or peg at left side of scale. When changed to 60.0 kHz, meter should move toward green ALIGN band and then jerk to black ALIGN mark when synthesizer phase locked loop locks.	If 100 Hz is available at XP8-11, 1 kHz (5 kHz for s/n 112 - 224) at XP8-13 and 3.6v at XP8-18, problem is within Synthesizer. When proper signals are not available at XP8-11 and -13, problem is within Divider if 500 kHz is available at XP2-9 and 900 kHz at XP2-14. When proper signals are not available at XP2-9 and -14, problem is within Phase Shifter.
c	To check receiver circuit.	Set 207 switches as follows: ANTENNA — HI Z RF ATTENUATION — 0 DECIBELS AUDIO — completely clockwise Hold a paper clip or short piece of wire to center conductor of ANTENNA connector.	When wire is held to ANTENNA connector, audio noise level will increase indicating that receiver is converting a signal.	If 50 KHz is available at XP19-7 and 111.1 KHz at XP20-5, check IF Amplifier, 1.1 KHz Mixer, 51.1 KHz Mixer, and Broadband RF Amplifier. When proper signals are not available at XP19-7 and XP20-5, trace source of trouble as outlined in last column of step b.
d	To check ACCUMULATIVE ERROR counter and Phase Shifter circuit.	Set ACCUMULATOR switch to ON and then hold SERVO PHASE switch first in ADVANCE and then in RETARD positions.	ACCUMULATIVE ERROR counter will advance and retard.	If proper signal is available at TP14 and TP15 of Phase Shifter, problem is in ACCUMULATIVE ERROR counter. When proper signals are not available at TP14 and TP15, problem is in Phase Shifter.
e	To check Phase Detector circuit.	Set FREQUENCY/KHz dials to 00.0.	NO SIGNAL lamp should go out and instrument should track up or down at selected TRACKING RATE without stopping.	Check for proper inputs to Phase Detector (XP1-14, -15, -21, and -22) and proper outputs of Phase Detector (XP-7, -18 and -19) before troubleshooting Phase Detector. When proper inputs and outputs are not available, localize problem using checks given in Figure 4-21.
f	To check 207-1-450 Whip Antenna.	Connect 207-1-450 antenna lead to ANTENNA connector at rear of instrument. Set FREQUENCY/KHz dials away from 00.0 and ANTENNA switch from 207-1-450 WHIP to 50 OHM.	Audio level should decrease.	Check Whip Antenna and antenna connections.

Figure 4-19. FRONT PANEL TROUBLE ISOLATING CHECKS

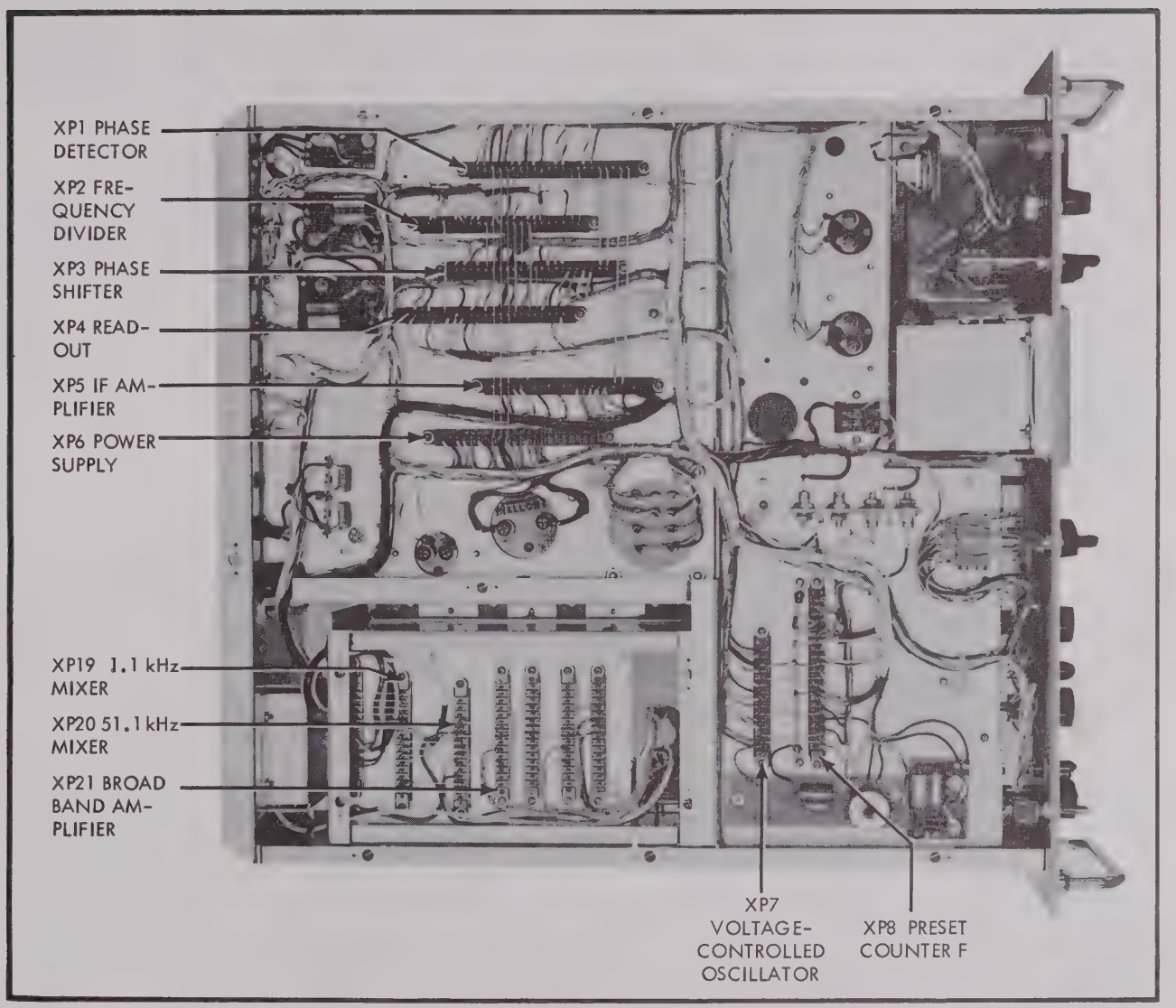


Figure 4-20. MODULE CONNECTOR LOCATIONS

b. Check for proper phase shifted waveforms at P3-5 as shown in Figure 4-23. The presents of the proper signals indicates that the input frequency selector circuit at the bottom of the schematic, the add and delete driver circuits, the phase inversion logic circuit, and the add pulse generator circuit are functioning properly. If the proper waveforms are not present, use steps c and d to further isolate the problem.

c. Check for the presence of proper 1 MHz waveforms at TP9 and TP10 as shown on schematic. If the proper waveforms are not available, trace signal through input frequency selector circuit as shown at bottom of schematic.

d. Check for proper outputs of add and delete drivers at the collectors of Q24 and Q26 respectively. If proper outputs are not available, check drive circuits as shown on schematic. If the proper signals are available, check phase inversion logic circuit and add pulse generator circuit.

e. Check for proper timing waveform at base of Q17 and Q21 in timing clock circuit. Note that Darlington pair Q21 - Q22 and Q17 - Q18 turn on when the base of Q17 and Q18 respectively reach approximately 1.2 volts. Also note that when one Darlington pair is turned on the other is turned off.

4-50. POWER SUPPLY TROUBLESHOOTING. The power supply circuits can be assumed to be operating properly if the following conditions exist:

a. The voltage of the +13 volt power supply should be 13.1 (±0.4) vdc (TP1 to TP3).

b. The voltage of the -13 volt power supply should be -13.1 (±0.4) vdc (TP2 to TP3).

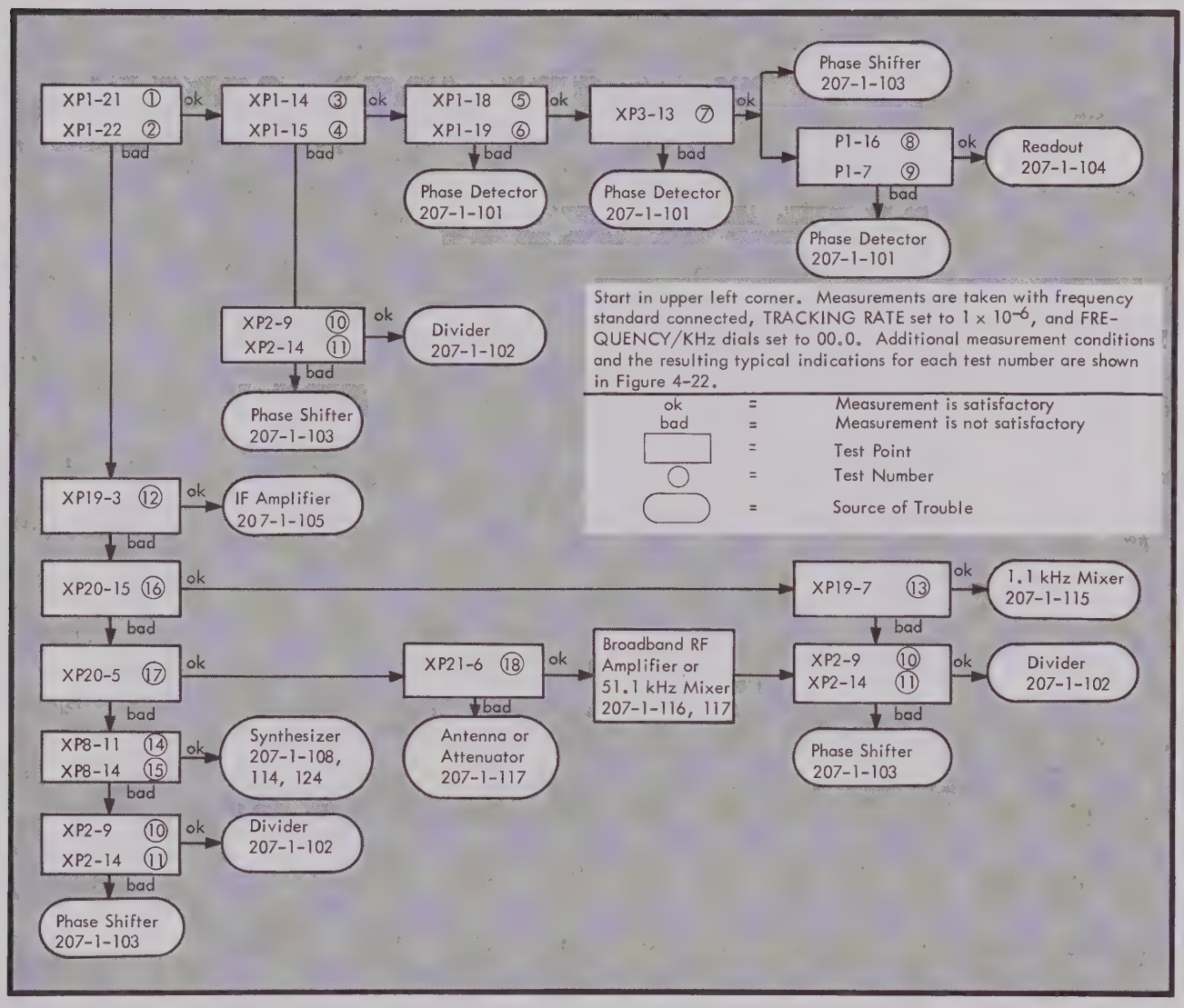


Figure 4-21. TROUBLE ISOLATION CHART

c. The voltage of all three 3.6 volt regulators should be between 3.2 and 3.8 vdc (emitter of A21Q5, A22Q5 and A23Q5 to ground).

d. The ripple of all five supplies should be less than 10 millivolts as measured with an rms voltmeter (TP1 to TP3, TP2 to TP3, and emitter of A21Q5, A22Q5 and Q23A5 to ground).

4-51. FREQUENCY SYNTHESIZER TROUBLESHOOTING. Troubles in the Frequency Synthesizer may be isolated to a stage or group of stages with the aid of the block diagram in Figure 4-24. In addition, the following hints will aid in troubleshooting the Frequency synthesizer.

a. If a counter connected to the CONV SYNTH output connector indicates no Frequency Synthesizer output, either the output ten-to-one divider circuit or the VCO is malfunctioning. Troubles in the ten-to-one divider circuit may be located with the JK Flip Flop troubleshooting technique explained under Divider Troubleshooting. Trouble in the VCO is best located, in most cases, by turning the instrument off and making resistance measurements. The resistance of the secondary windings of transformers T1 through T5 is 0.4 ohms each giving a total of about 2 ohms as measured from TP1 to ground. The primary of transformers T1 through T5 should each have a resistance of approximately 1 to 2 ohms. A shorted tunning capacitor is best found by taking resistance measurements from the collector of Q1 to the common side of transformers T1 through T5 at each setting of the FREQUENCY/KHz dials.

b. If the output frequency is incorrect at some FREQUENCY/KHz dial settings, the trouble could be due to a defective diode connected to one of the digit switches, one of the JK Flip Flop ICs, or a digit switch.

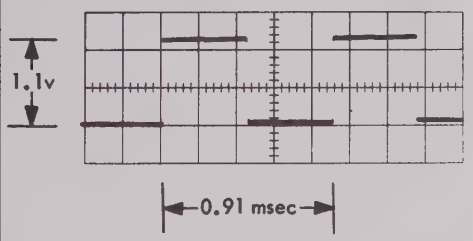
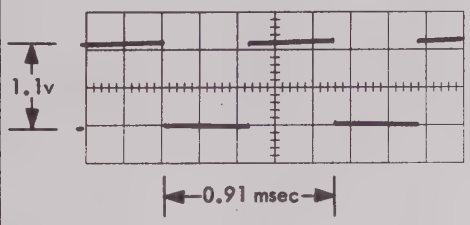
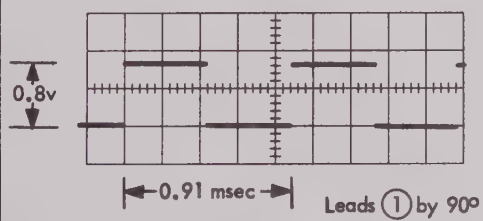
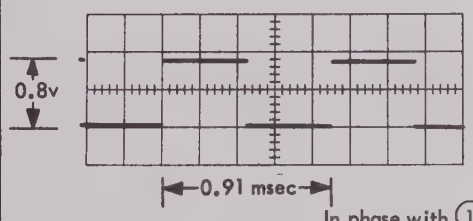
TEST NUMBER AND TEST POINT	MEASUREMENT CONDITIONS	TYPICAL INDICATION
① XP1-21	0.2 msec/cm 0.5v/cm External trigger from 100 Hz COHERENT OUTPUT 10 uv (1v - 100 db) at 60 kHz applied to ANTENNA input connector FREQUENCY/KHz dials set to 60.0	
② XP1-22	0.2 msec/cm 0.5v/cm External trigger from 100 Hz COHERENT OUTPUT 10 uv (1v - 100 db) at 60 kHz applied to ANTENNA input connector FREQUENCY/KHz dials set to 60.0	 180° out of phase with ①
③ XP1-14	0.2 msec/cm 0.5v/cm External trigger from 100 Hz COHERENT OUTPUT	 Leads ① by 90°
④ XP1-15	0.2 msec/cm 0.5v/cm External trigger from 100 Hz COHERENT OUTPUT	 In phase with ①
⑤ XP1-18	FREQUENCY/KHz dials set to 0.00 Frequency standard disconnected ACCUMULATIVE ERROR counter counting up ACCUMULATIVE ERROR counter counting down	 0 vdc 1.36 vdc 1.32 vdc
⑥ XP1-19	FREQUENCY/KHz dials set to 0.00 Frequency standard disconnected ACCUMULATIVE ERROR counter counting up ACCUMULATIVE ERROR counter counting down	 0.75 vdc 0 vdc 1.39 vdc
⑦ XP3-13	FREQUENCY/KHz dials set to 0.00 Frequency standard disconnected ACCUMULATIVE ERROR counter counting up ACCUMULATIVE ERROR counter counting down	 3.1 vdc 10.6 vdc 10.4 vdc

Figure 4-22. MEASUREMENTS USED TO ISOLATE TROUBLES TO A MODULE (sheet 1 of 3)

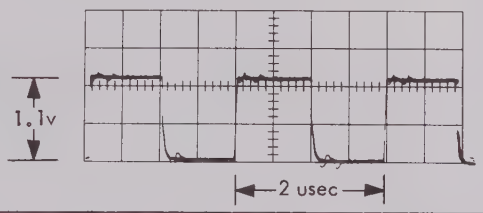
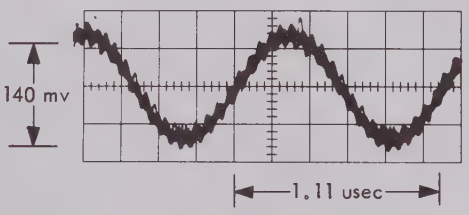
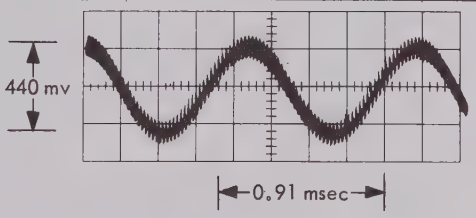
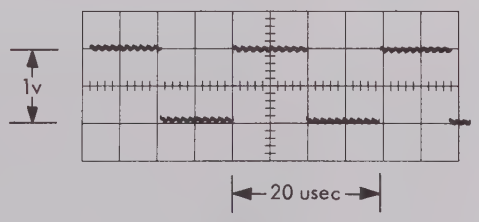
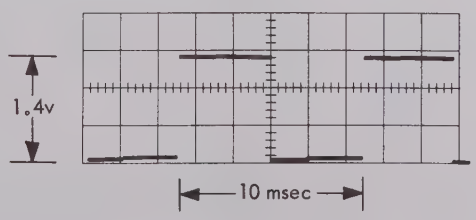
TEST NUMBER AND TEST POINT	MEASUREMENT CONDITIONS	TYPICAL INDICATION
⑧ XP1-16	FREQUENCY/KHz dials set to 0.00	
	Meter needle deflecting right with METER FUNCTION switch set to SIG PD	0.76 vdc
	Meter needle deffecting left with METER FUNCTION switch set to SIG PD	0 vdc
⑨ XP1-7	FREQUENCY/KHz dials set to 00.0	
	Frequency standard disconnected ACCUMULATIVE ERROR counter counting up ACCUMULATIVE ERROR counter counting down	0.13 vdc 0.73 vdc 0.74 vdc
⑩ XP2-9	0.5 usec/cm 0.5v/cm	
⑪ XP2-14	0.2 usec/cm 0.5v/cm	
⑫ XP19-3	0.2 msec/cm 0.2v/cm 1 mv (1v - 60 db) at 60 kHz applied to ANTENNA input counter	
⑬ XP19-7	5 usec/cm 0.5v/cm	
⑭ XP8-11	2 msec/cm 0.5v/cm	

Figure 4-22. MEASUREMENTS USED TO ISOLATE TROUBLES TO A MODULE (sheet 2 of 3)

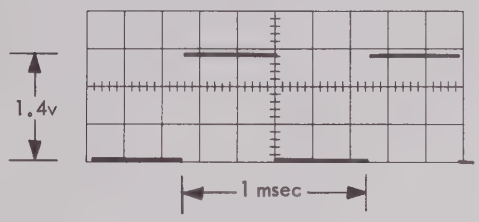
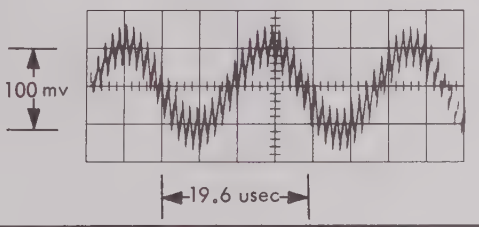
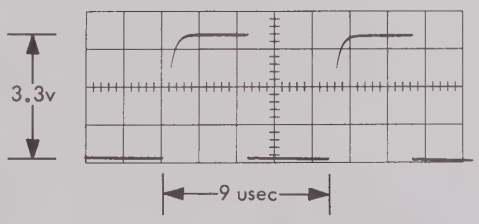
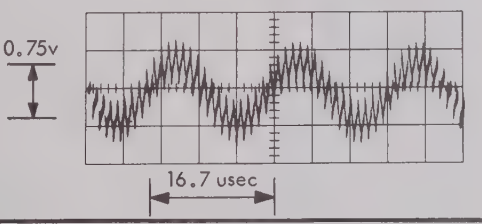
TEST NUMBER AND TEST POINT	MEASUREMENT CONDITIONS	TYPICAL INDICATION
⑮ XP8-13	0.2 msec/cm 0.5v/cm For serial numbers 112 to 224 50 usec/cm 0.5v/cm	 Waveform will have a frequency of 5 kHz (0.2 msec) instead of 1 kHz (1 msec)
⑯ XP20-15	5 usec/cm 0.05v/cm 3.16 mv (1v - 50 db) at 60 kHz applied to ANTENNA input connector	
⑰ XP20-5	2 usec/cm 1v/cm	
⑱ XP21-6	5 usec/cm 0.05v/cm	

Figure 4-22. MEASUREMENTS USED TO ISOLATE TROUBLES TO A MODULE (sheet 3 of 3)

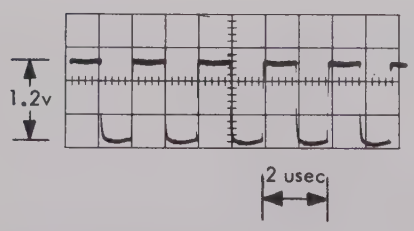
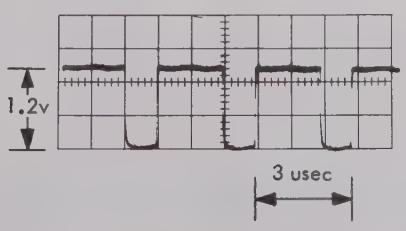
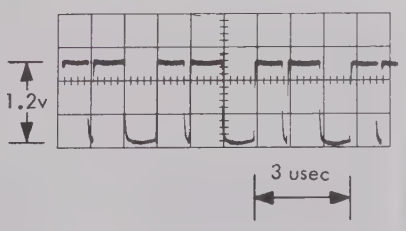
500 kHz waveform without phase shifting	Delete pulse waveform - with TP18 grounded and SERVO PHASE switch held to ADVANCE.	Add pulse waveform - with TP18 grounded and SERVO PHASE switch held to RETARD.
		
1 usec/cm 0.5 v/cm		

Figure 4-23. 500 kHz WAVEFORM AT P3-5

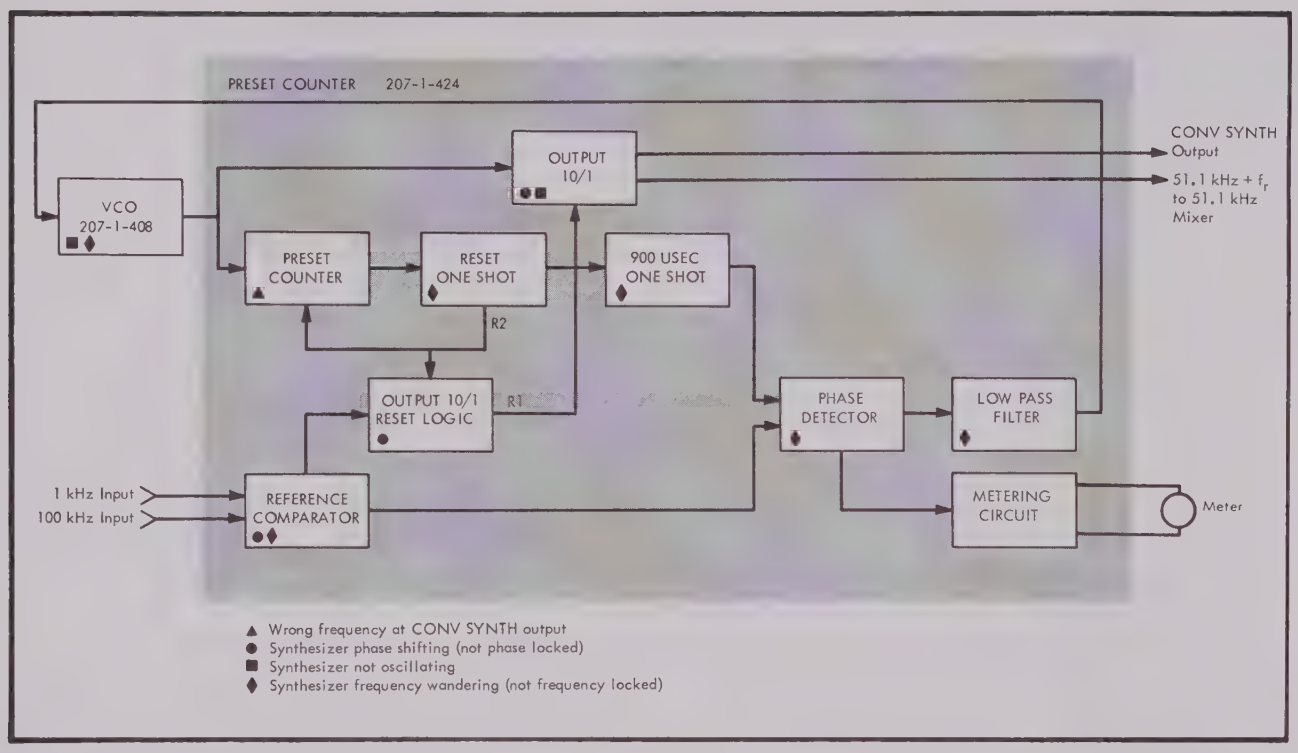


Figure 4-24. SYNTHESIZER TROUBLESHOOTING

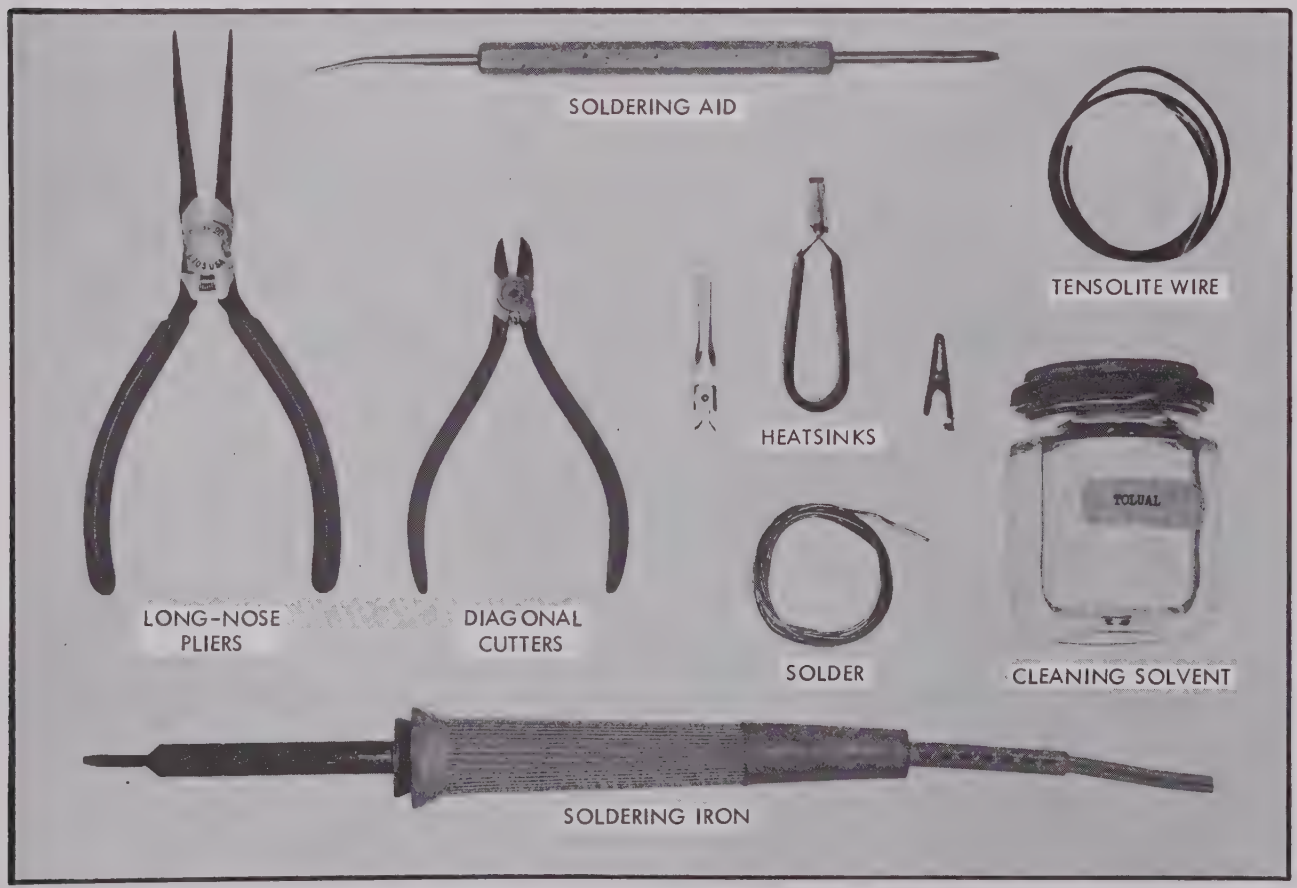


Figure 4-25. TOOLS REQUIRED FOR SOLDERING

c. Trouble in the preset counter, JK Flip Flop divider circuits, may be located using the technique explained under Divider Troubleshooting.

d. When the Frequency Synthesizer is locked onto the frequency set on the FREQUENCY/KHz dials, the output voltage of the low pass filter (P8-17 to P8-18) should be 1.95 (±0.1) volts dc. Shorting TP2 to TP6 should cause this voltage to increase to 3.4 (±0.25) volts dc.

4-52. RECORDER TROUBLESHOOTING. The Rustrak Instrument Company recommends that the galvanometer or other major parts of the recorder be repaired only by the factory. If trouble develops that requires factory assistance, package recorder and affix a letter giving all details of the trouble to the outside of the package. Forward the package to:

Rustrack Instrument Company, Inc.
Municipal Airport
Manchester, New Hampshire 03103
Attention: Service Department

4-53. SOLDERING TECHNIQUES

4-54. Certain soldering techniques are extensively used at FLUKE to insure the finest quality soldering connections. Some of these techniques are useful for maintaining and repairing instruments. The following paragraphs provide information on tinning a soldering iron, removing solder from a connection, and using heat sinks. Figure 4-25 illustrates some of the soldering tools and aids used at FLUKE.

4-55. TINNING A SOLDERING IRON. Before heating the iron, file all sides of the wedge portion of the tip that will be used. A smooth surface will prevent solder from building up on rough spots and burrs where it can rapidly oxidize. Allow the iron to heat to the proper temperature for tinning. If a small piece of solder is supported on the tip, it will start to melt when the right temperature for tinning is reached. Be sure the iron does not get to hot before tinning or the solder may oxidize resulting in improper tinning.

4-56. REMOVING SOLDER FROM A CONNECTION. Most solder connections consist of a terminal to which a wire or electrical component is connected. To ensure a strong mechanical connection, the wire or component lead is wrapped around or over the terminal. If the wire or component must be removed, it is extremely difficult to free the wire from the terminal. This is especially true of printed circuit boards where applying excessive heat or mechanical stress may break the land pattern away from the laminated epoxy.

4-57. Solder may be easily removed from a connection by using a soldering iron and a piece of wire as illustrated in Figure 4-26. The wire can be a braided wire shield, stripped from small unusable pieces of shielded coaxial cable, or a special wire produced by Tensolite Inc. The Tensolite wire is constructed of 65 strands of #40 tined copper wire covered with a type of silicon rubber. Because of the numerous strands of wire, the solder is drawn up the wire by capillary action. Dipping the wire in rosin flux will aid the capillary action. When the end becomes saturated with solder it can be clipped off and more insulation stripped off to form a clean end. The silicon rubber provides insulation from the heat transferred up the wire.

4-58. Many printed circuit boards have been coated with epecaste, a polyurethane resin, to inhibit fungus growth or moisture absorbtion. The heat from the soldering iron decomposes the epecaste into carbon dioxide and water. It is therefore necessary to clean the disturbed area with a solvent such as tolual that will disolve the decomposed epecaste that has not vaporized.

WARNING!

Avoid inhaling the vapor of tolual or excessive contact with the skin. Also, keep tolual away from open flames. Make sure tolual does not get on any of the components as it may disolve some parts of the components.

The disturbed area of the circuit board should then be recoated. A spray can of Circuit Coate (Furane Plastic Inc, 4516 Brazil Street, Los Angeles, California or 16 Spielman Road, Fairfield, New Jersey) may be used for recoating.

4-59. USING HEAT SINKS. Certain components such as diodes, transistors, and integrated circuits can be damaged if excessive heat is applied to the leads. Thus, a heat sink should be inserted between the soldering iron and the component. Figure 4-27 illustrates the use of long nose pliers as a heatsink. A common alligator clip will also serve quite well as a heat sink when commercial types such as the one shown in Figure 4-25 are not available.

4-60. REPAIRING THE FREQUENCY SYNTHESIZER

4-61. Ordinarily the Frequency Synthesizer should never require repair due to its highly reliable solid state design. However, if a problem does arise, use the instructions in the following paragraphs for removing, disassembling and installing the Frequency Synthesizer.

4-62. FREQUENCY SYNTHESIZER REMOVAL. The Frequency Synthesizer may be removed from the instrument as follows:

a. Remove top and bottom covers.

b. Remove four screws holding Synthesizer to bottom of instrument (see Figure 4-28).

c. Remove RF ATTENUATOR, TRACKING RATE, RF FILTER and three FREQUENCY/KHz switch knobs using a 5/64 inch and 1/16 inch hex-key wrench (see Figure 4-28).

d. Remove nylon bushings from shafts of RF ATTENUATOR, TRACKING RATE and RF FILTER switches.

e. Raise instrument about 2 inches off work surface by setting it on supports such as a few pieces of two-by-fours.

f. Remove three screws from each side of front panel, screw from upper center of front panel and spacer from just behind upper center of front panel.

g. Set front panel on work surface being careful not to break any wires.

h. Remove two screws from front (and one screw from side for first few hundred instruments) of Synthesizer (see Figure 4-28).

i. Unplug Synthesizer by rocking diagonal corners of Synthesizer chassis.

4-63. FREQUENCY SYNTHESIZER DISASSEMBLY AND ASSEMBLY. Because of the demanding electronic requirements of the Frequency Synthesizer, it is difficult and time comsuming to completely disassemble the Frequency Synthesizer for anyone but factory trained personnel using special assembly tools. When complete disassembly becomes necessary, it is recommended that the Frequency Synthesizer be returned to the factory. However, the majority of all repaires, can be made by partial disassembly. For example, the printed circuit side of the VCO may be reached by removing the four screws holding it to the Synthesizer Assembly. In addition, both sides of most components on the Preset Counter "F" board may be reached by removing the VCO board and the rear chassis plate. When it becomes necessary to cut the wires connecting the Preset Counter "A" through "F" board, Figure 4-29 may be used as a guide for reassembly.

4-64. FREQUENCY SYNTHESIZER INSTALLATION. The Frequency Synthesizer may be installed in the instrument as follows:

a. Plug Synthesizer firmly into instrument.

b. Install two screws on front of Synthesizer (see Figure 4-28).

c. Fasten front panel to instrument using long screw and spacer at upper center of front panel and then three screws at each side of front panel.

d. Place nylon bushing on shafts of RF ATTENUATOR, TRACKING RATE and RF FILTER switch knobs (see Figure 4-28).

e. Install RF ATTENUATOR, TRACKING RATE, RF FILTER and three FREQUENCY/KHz knobs using a 5/64 inch and 1/16 inch hex-key wrench.

f. Install four screws that hold synthesizer to bottom of instrument (see Figure 4-28).

g. Install top and bottom covers.

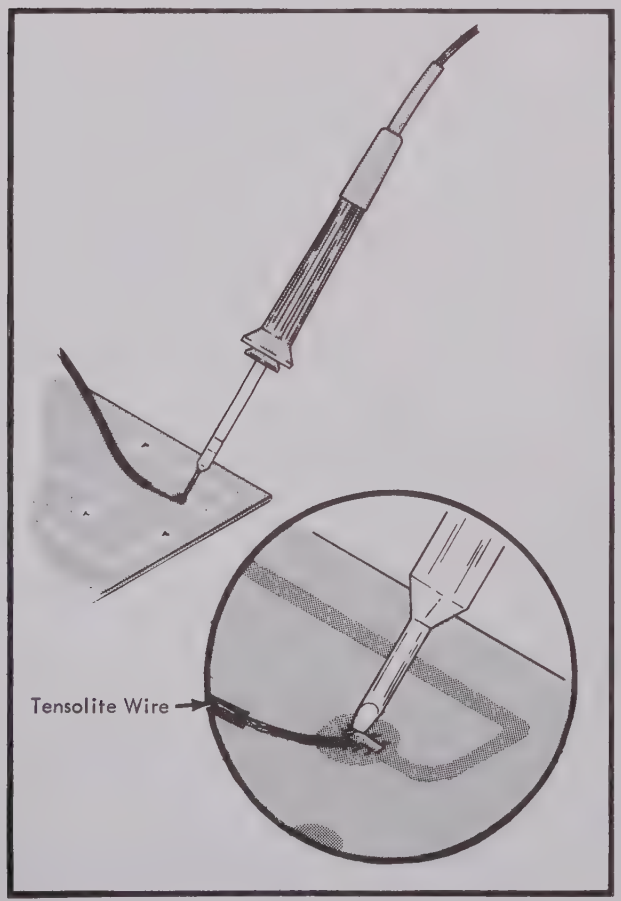


Figure 4-26. REMOVING SOLDER FROM A CONNECTION

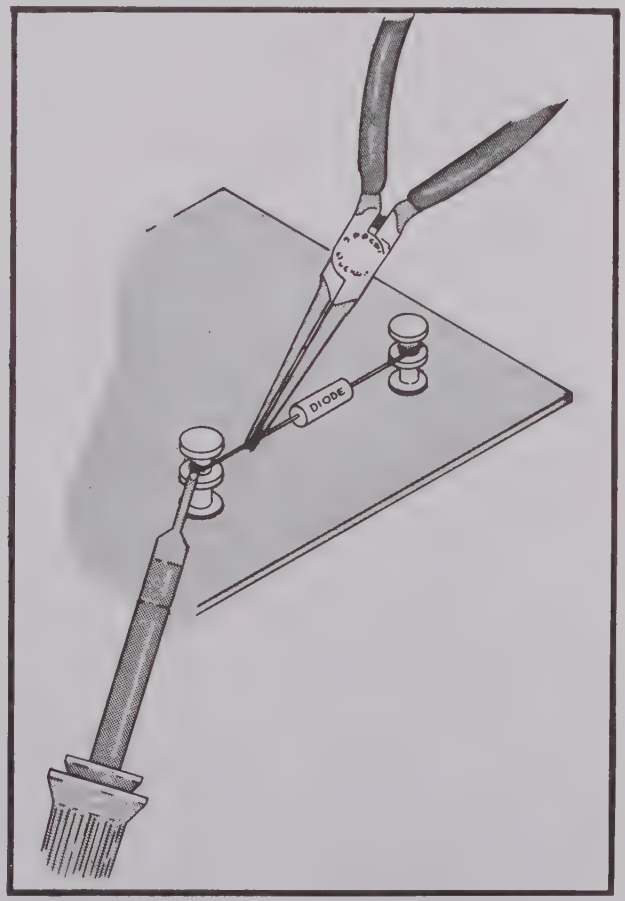


Figure 4-27. LONG-NOSE PLIERS USED AS A HEATSINK

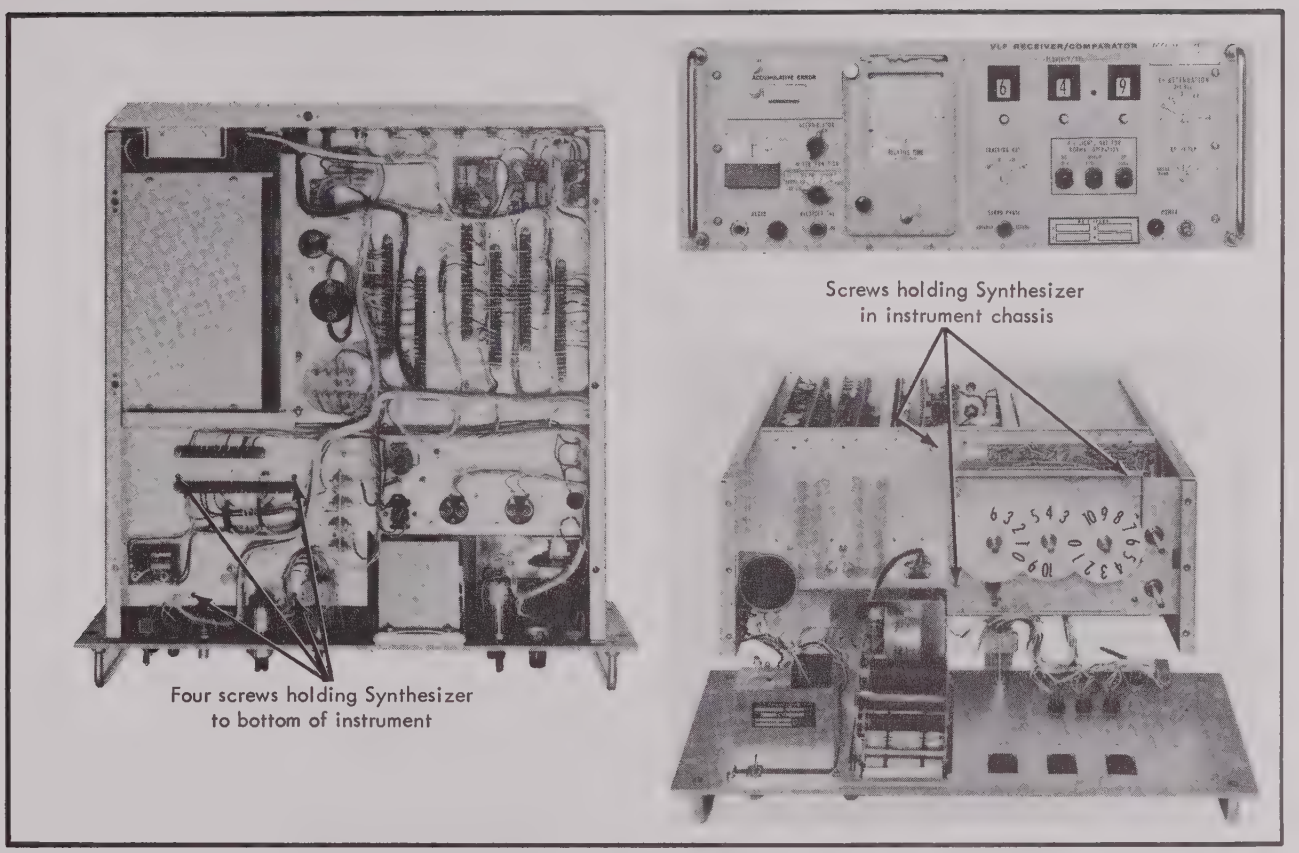


Figure 4-28. SYNTHESIZER REMOVAL

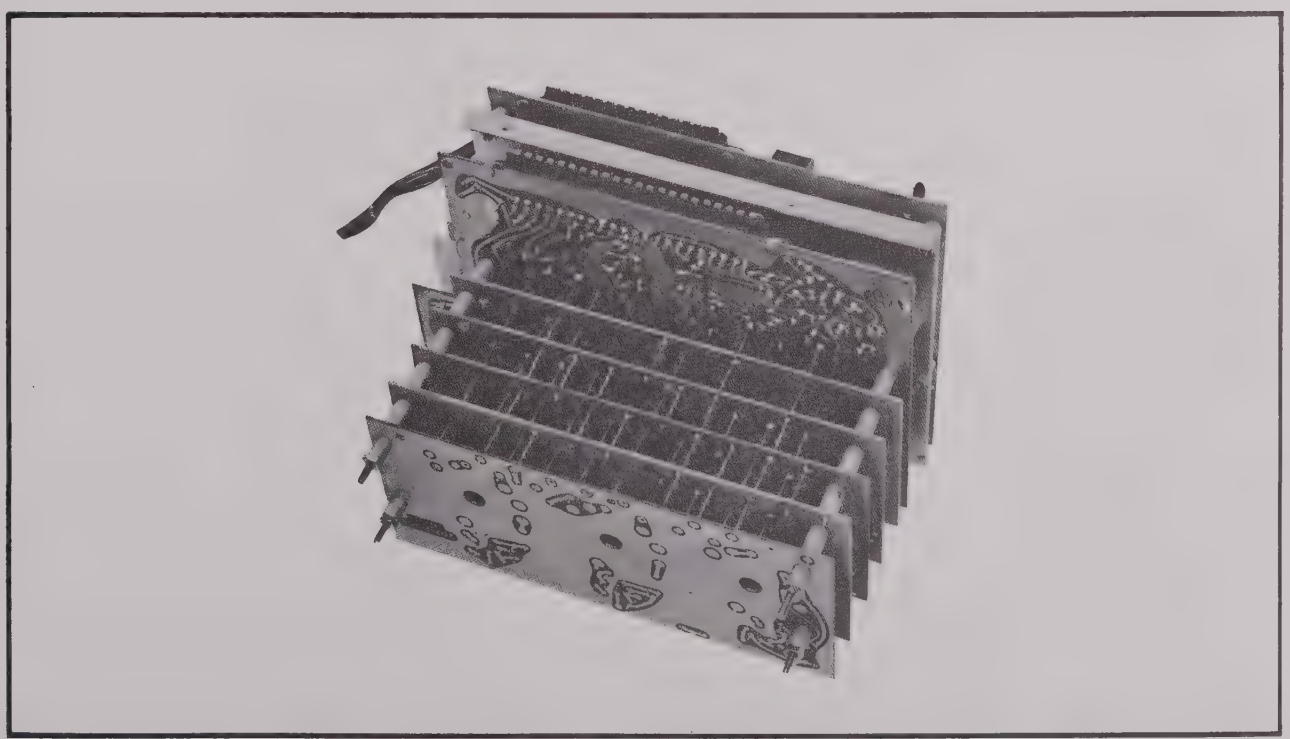


Figure 4-29. PRESET COUNTER "A" THROUGH "F" BOARD WIRE CONNECTIONS

SECTION V

LIST OF REPLACEABLE PARTS

5-1. INTRODUCTION

5-2. This section contains complete descriptions of those parts one might normally expect to replace during the life of the instrument. The first listing, Final Assembly, is a breakdown of all the major assemblies in the instrument. Subsequent listings itemize the components in each assembly. Each listing is accompanied by an illustration showing the location of the components. Assemblies and subassemblies are identified by a reference designation beginning with the letter A, e.g. A1, A5, A10, etc. Components are identified by the schematic diagram reference designation.

5-3. COLUMNAR INFORMATION

a. The REF. DESIG. column indicates the reference designation used on the schematic diagram.

b. The LOCATION column lists coordinates which locate the designated part on the associated illustration.

c. The DESCRIPTION column describes the part in words, along with any applicable values, tolerances, etc. Indentation is used to show assembly, subassembly, and parts relationship.

d. The STOCK NO. column indicates the number by which MONTRONICS stocks the part. This number should be used when ordering parts from the MONTRONICS factory or from your local MONTRONICS representative.

e. Entries in the MFR. column indicate a typical manufacturer of the part by the Federal Manufacturers Code.

f. The MFR. PART NO. column indicates the part number assigned by the manufacturer indicated in the MFR. column.

g. The TOT QTY column lists the total quantity of the item used in the Model 207-1. Second and subsequent listings of the same item are referenced to the first listing with the abbreviation REF. In the case of optional subassemblies, plug ins, etc. that are not always part of the instrument, the TOT QTY column lists the total quantity of the item in that particular assembly.

h. Entries in the REC QTY column indicate the recommended number of spare parts necessary to support one to five instruments for a period of two years. This list presumes an availability of common electronic parts at the maintenance site. For maintenance for one year or more at an isolated site, it is recommended that at least one of every part in the instrument be stocked.

i. The USE CODE column identifies certain parts which have been added, deleted or modified during the production of the instrument. Each part for which a Use Code has been assigned may be identified with a particular instrument serial number by consulting the Serial Number Effectivity List at the end of the parts list. As Use Codes are added to the list, the TOT QTY column listings are changed to reflect the most current information. Sometimes when a part is changed, the new part can and should be used as a replacement for the original part. In this event a parenthetical note is added in the DESCRIPTION column.

5-4. HOW TO OBTAIN PARTS

5-5. Standard components have been used wherever possible. Thus, most parts can be obtained locally. However, parts may be ordered directly from the manufacturer's part number. Or they may be ordered from the Montronics, Inc. factory or authorized representative. In the event the part you order has been replaced by a new or improved part, the replacement will be accompanied by an explanatory note and installation instructions, if necessary.

5-6. You can insure prompt and efficient handling of your order to Montronics, Inc. if you include the following information:

a. Instrument model and serial number.
b. Component description.
c. Component reference designation.
d. Montronics, Inc. part number.

If you must order structural parts not listed in the parts list, describe the part as completely as possible. A sketch of the part showing its location to other parts of the instrument is usually most helpful.

5-7. LIST OF ABBREVIATIONS

ac	alternating current
Al	Aluminum
amp	ampere
assy	assembly
cap	capacitor
car flm	carbon film
C	centigrade
cer	ceramic
comp	composition
conn	connector
db	decibel
dc	direct current
dpdt	double-pole, double-throw
dpst	double-pole, single-throw
elect	electrolytic
F	fahrenheit
Ge	germanium
gmv	guaranteed minimum value
h	henry
Hz	hertz
hf	high frequency
IC	integrated circuit
if	intermediate frequency
k	kilohm
kHz	kilohertz
kv	kilovolt
lf	low frequency
MHz	megahertz
M	megohm
met flm	metal film
ua	microampere
uf	microfarad
uh	microhenry
usec	microsecond
uv	microvolt
ma	millampere
mh	millihenry
m	millohms
msec	millisecond
mv	millivolt
mw	milliwatt
na	naoampere
nsec	nanosecond
nv	nanovolt
Ω	ohm
ppm	parts per million
piv	peak inverse voltage
p-p	peak to peak
pf	picofarad
plstc	plastic
p	pole
pos	position
P/C	printed circuit
rf	radio frequency
rfi	radio frequency interference
res	resistor
rms	root mean square
rtry	rotary
sec	second
sect	section
S/N	serial number
Si	silicon
scr	silcon controlled rectifier
spdt	single-pole, double-throw
spst	single-pole, single-throw
sw	switch
Ta	tantalum
tstr	transistor
tvm	transistor voltmeter
uhf	ultr high frequency
vtvm	vacuum tube voltmeter
var	variable
vhf	very high frequency
vlf	very low frequency
v	volt
va	voltampere
vac	volts, alternating current
vdc	volts, direct current
w	watt
ww	wire wound

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
		MODEL 207 FINAL ASSEMBLY **Figure 5-1**						
A1		Chassis Assembly (See Figure 5-2)						
A2		Front Panel Assembly (See Figure 5-3)						
A3		Rear Panel Assembly (See Figure 5-4)						
A4		Phase Detector Module (See Figure 5-5)	1702-191460 (207-1-401)	19429	1702-191460	1		
A5		Frequency Divider Module (See Figure 5-6)	1702-191478 (207-1-402)	19429	1702-191478	1		
A6		Phase Shifter Module (See Figure 5-7)	1702-191486 (207-1-403)	19429	1702-191486	1		
A7		Readout Module (See Figure 5-8)	1702-191494 (207-1-404)	19429	1702-191494	1		
A8		IF Amplifier Module (See Figure 5-9)	1702-191502 (207-1-405)	19429	1702-191502	1		
A9		Power Supply Module (See Figure 5-10)	1702-191510 (207-1-406)	19429	1702-191510	1		
A10		Frequency Synthesizer Assembly (See Figure 5-11)	3158-191742 (207-1-431)	19429	3158-191742	1		
A11		RF Enclosure Assembly (See Figure 5-17)	3158-191924 (207-1-430)	19429	3158-191924	1		
A12		1.1 kHz Mixer Module (See Figure 5-18)	1702-191601 (207-1-415)	19429	1702-191601	1		
A13		5.1 kHz Mixer Module (See Figure 5-19)	1702-191619 (207-1-416)	19429	1702-191619	1		
A14		Broad Band RF Amplifier Module (See Figure 5-20)	1702-191627 (207-1-417)	19429	1702-191627	1		
A15		Internal Frequency Standard Assembly (207-4, -5, only)	1301-183640	13839	Model IL			
A16		Strip Chart Recorder (See Figure 5-21)	4301-179606	14869	Model 88	1		
A17		Optional Battery Pack (207-4B, -5B only) (See Figure 5-22)	207-4B-499	19429	207-4B-499			
A18		Whip Antenna Assembly (See Figure 5-23)	1200-191908 (207-1-450)	19429	1200-191908	1		
A19		Accessories Kit (See Figure 5-24)	3001-191866 (207-1-445)	19429	3001-191866	1		

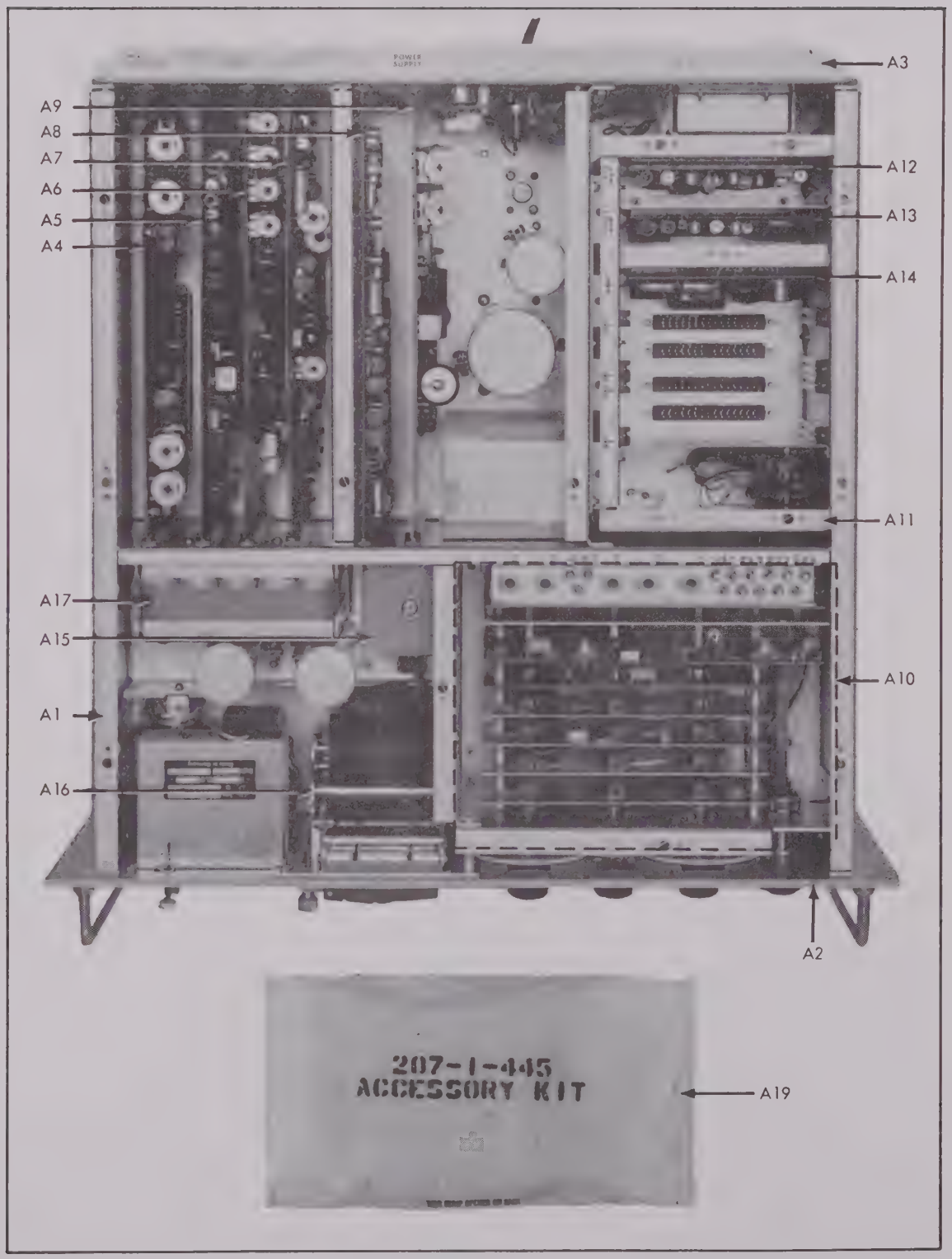


Figure 5-1. MODEL 207 FINAL ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A1		CHASSIS ASSEMBLY - Figure 5-2						
A20	F4-P1	External Power Changeover Assy. (See Figure 5-2)	1702-191676 (207-1-423)	19429	1702-191676	1		
A21	K3-T1	3.6v Regulator Assembly (See Figure 5-2)	1702-191528 (207-1-407)	19429	1702-191528	3		
A22	K3-T4	3.6v Regulator Assembly (See Figure 5-2)	1702-191528 (207-1-407)	19429	1702-191528	REF		
A23	K3-U2	3.6v Regulator Assembly (See Figure 5-2)	1702-191528 (207-1-407)	19429	1702-191528	REF		
C1	I5-R2	Cap, elect, 4,500 uf +75/-10%, 50v	1502-170399	37942	CG452U50D1	1	1	
C2	J4-R1	Cap, elect, 2,000 uf +75/-10%, 50v	1502-180430	37942	CG202U50C1	2	1	
C3	G2-S4	Cap, elect, 3,300 uf +75/-10%, 35v	1502-180422	37942	CG332U35K1	1	1	
C4	G2-T4	Cap, elect, 2,000 uf +75/-10%, 50v	1502-180430	37942	CG202U50C1	REF		
C5	K3-R4	Cap, mylar, 0.0075 uf ±10%, 600v	1507-168443	37942	PVC6275	2		E
C5	K3-R4	Cap, cer, 0.01 uf +80/-20%, 600v	1501-105668	56289	29C9B5	2		F
C6	K3-R2	Cap, mylar, 0.0075 uf ±10%, 600v	1507-168443	37942	PVC6275	REF		E
C6	K3-R2	Cap, cer, 0.01 uf +80/-20%, 600v	1501-105668	56289	29C9B5	REF		F
CR1	F5-R3	Diode, Type 1N342A	4802-182998	81483	Type 1N342A	4	2	
CR2	G1-R3	Diode, Type 1N342A	4802-182998	81483	Type 1N342A	REF		
CR3	G3-R3	Diode, Type 1N342A	4802-182998	81483	Type 1N342A	REF		
CR4	G4-R3	Diode, Type 1N342A	4802-182998	81483	Type 1N342A	REF		
CR5	G3-Q3	Diode, Type 1N270	4802-149187	94145	Type 1N270	57	8	
CR6	G5-Q3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR7	I5-S4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
SP1	F4-U1	Loudspeaker, 2-1/4 inch, 100Ω	1900-170464	74199	22A062100	1		
Q3	K2-R1	Transistor, RCA Type 40250 (207-4B, -5B only)	4805-183004	49671	Type 40250			
R6	H1-S1	Res, met flm, 23.7k ±1%, 1/8w (207-4, -5 only)	4705-188347	12400	Type CEA T-O			
R8	I5-T5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	56		
R9	G3-Q3	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	11		
R10	G4-Q3	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
T1	H5-R2	Transformer, power	5600-185796	19429	5600-185796	1		
XJ1	I1-U2	Connector, female, 22 contact, chassis mount	2107-149393	95354	SD622S	7	1	
XJ2	I3-T4	Connector, female, 22 contact, chassis mount	2107-149393	95354	SD622S	REF		
XJ3	I2-T2	Connector, female, 22 contact, chassis mount	2107-149393	95354	SD622S	REF		
XJ4	I4-S5	Connector, female, 22 contact, chassis mount	2107-149393	95354	SD622S	REF		
XJ5	H5-S3	Connector, female, 22 contact, chassis mount	2107-149393	95354	SD622S	REF		
XJ6	I2-R5	Connector, female, 22 contact, chassis mount	2107-149393	95354	SD622S	REF		
XJ7	H1-Q2	Connector, female, 15 contact, chassis mount	2107-183202	95354	SD615S	8	1	

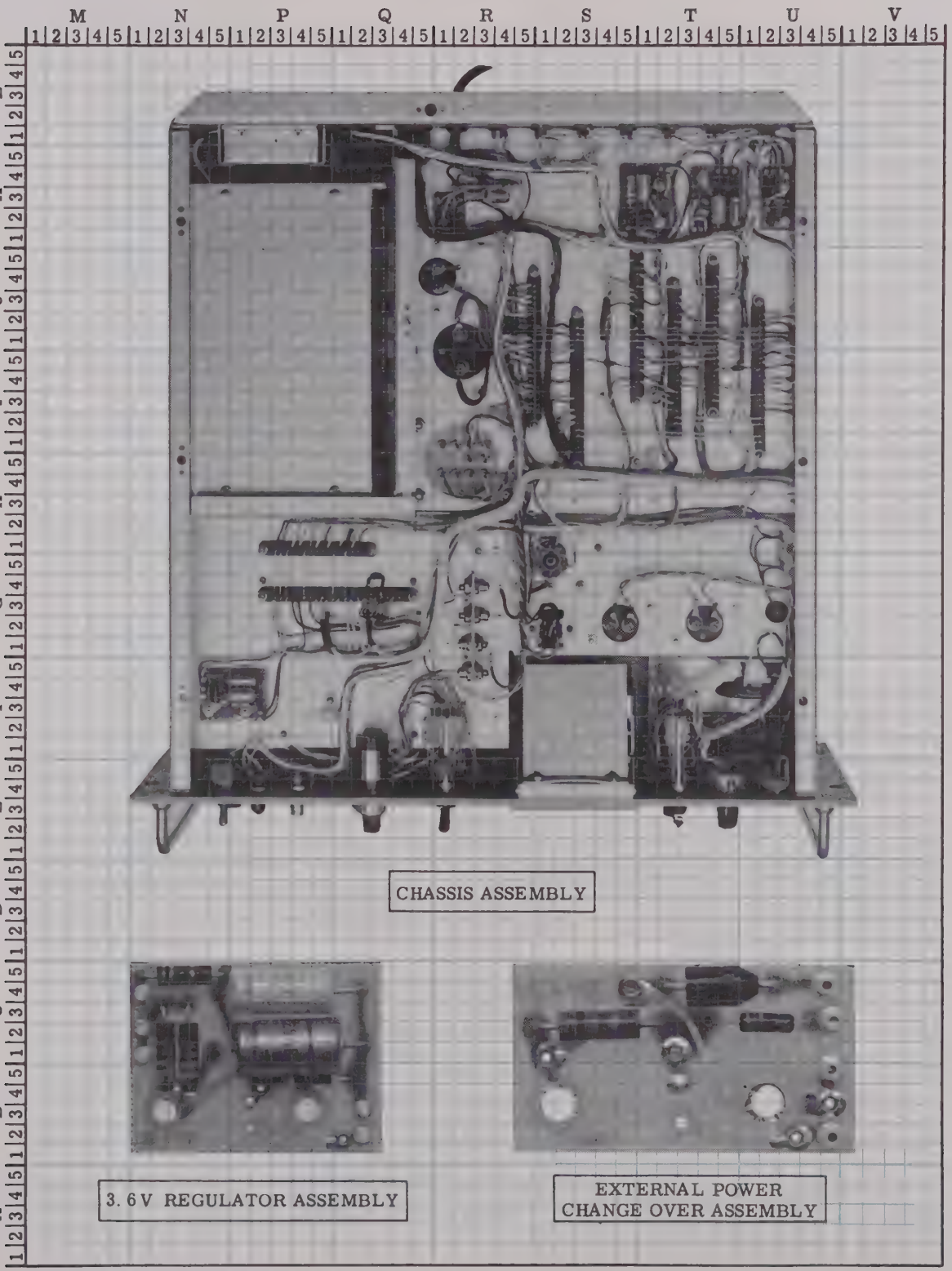


Figure 5-2. CHASSIS ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
XJ8	G3-Q4	Connector, female, 22 contact, chassis mount	2107-149393	95354	SD622S	REF		
XJ9	G2-S1	Receptacle, female, 6 contact	2100-170472	71785	5306-AB	1		
XJ10	G5-S1	Socket, 8 pin (207-4, -5 only)	2112-100404	71785	9711			
		Card slides (not illustrated)	3155-183228	19429	3155-183228	4		
	L4-R2	Cord, power	6005-102822	70903	KH-4616	1		
		Feet, plastic (not illustrated)	2819-102921	16742	Glide-.04300	4		
A20		**EXTERNAL POWER CHANGEOVER ASSEMBLY - Figure 5-2**	1702-191676 (207-1-423)	19429	1702-191676	REF		
CR1	C4-T5	Diode, Type 1N4317	4802-116111	05277	Type 1N4817	17	4	
CR2	C3-U2	Diode, zener, 6.2v, Type 1N753	4803-180497	07910	Type 1N753	4	1	
Q4	[1]	Transistor, RCA Type 40250	4805-183004	49671	Type 40250	7	2	
R1	C2-S4	Res, comp. 100Ω ±5%, 1/2w	4704-188508	01121	EB1015	1		
A21, A22, A23		**3.6 VOLT REGULATOR ASSEMBLY Figure 5-2**	1702-191528 (207-1-407)	19429	1702-191528	REF		
C1	C4-P3	Cap, elect, 50 uf +75/-10%, 6v	1502-187641	56289	30D506G006-CB4	6	1	
C2	C1-P3	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	29	1	
CR1	B5-P5	Diode, Type 1N749A	4802-180455	07910	Type 1N749A	4	1	
Q5	[1]	Transistor, RCA Type 40250	4805-183004	95303	Type 40250	REF		
R1	C5-N3	Res, comp, 330Ω ±5%, 1/2w	4704-108936	01121	EB3315	3		
R2	C1-N2	Res, comp, 3.3Ω ±5%, 1/2w	4704-188482	01121	EB33G5	6		
R3	C1-N4	Res, comp, 3.3Ω ±5%, 1/2w	4704-188482	01121	EB33G5	REF		

[1] Mounted on chassis directly above assembly.

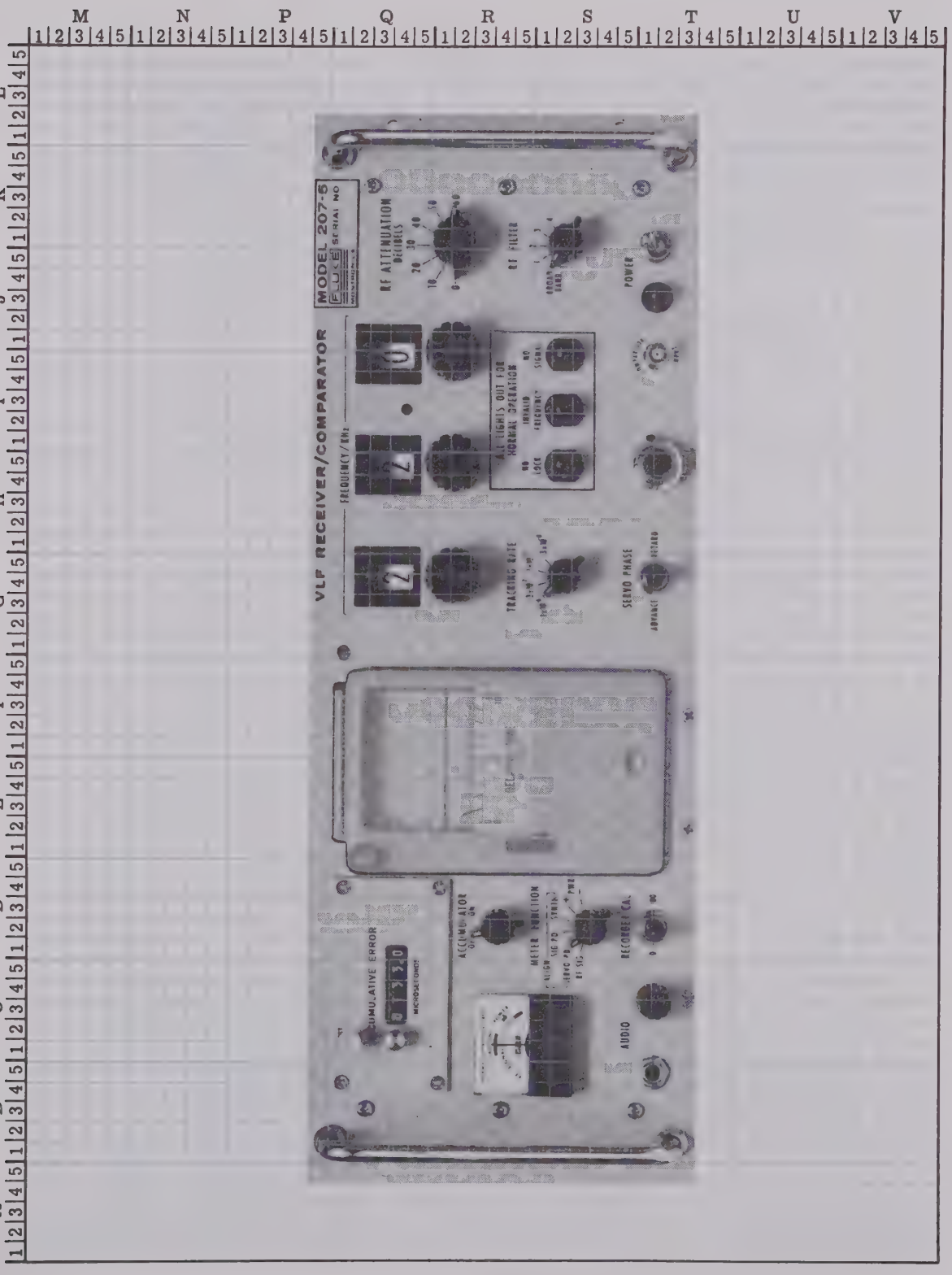


Figure 5-3. FRONT PANEL ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A2		**FRONT PANEL ASSEMBLY** Figure 5-3						
A24	D2-S2	Meter Function Switch Assembly	5110-191775	19429	5110-191775	1		
C7, C8		Cap, cer, 0.05 uf ±20%, 50v (not illustrated, attached to S4)	1501-149161	56289	55C23A1	33		
DS1	J4-T1	Lamp, incandescent, 28v, Type 327	3901-153106	71744	Type 327	4	2	
DS2	J1-S2	Lamp, incandescent, 28v, Type 327	3901-153106	71744	Type 327	REF		
DS3	I3-S2	Lamp, incandescent, 28v, Type 327	3901-153106	71744	Type 327	REF		
DS4	H5-S2	Lamp, incandescent, 28v, Type 327	3901-153106	71744	Type 327	REF		
J18	I5-T1	Connector, female, Type BNC	2106-152033	02660	UG1094/U			
J26	B5-T1	Jack, telephone, 3 terminals	2109-170498	82389	L-12A	1		
M1	C1-R5	Meter, 500-0-500 ua, 77Ω	2901-183244	38315	MS-1T	1		
M2	C5-Q2	Directional counter	4300-170639	12323	F-160C	1		
R1	C3-T2	Res, var, ww, 5k ±20%, 1w	4702-170688	01121	Type J	1		
R5	H5-T2	Res, var, ww, 50k ±3%, 1-1/2w (207-4, -5 only)	4702-188946	73138	7216R50KL25			
R7		Res, comp, 470Ω ±5%, 1/2w (not illustrated, attached to S3)	4704-108787	01121	EB4715	1		
S1	D2-T2	Switch, toggle, spdt	5106-184333	82389	13033	1		
S3	D2-R4	Switch, rotary, 1p, 2 pos, 1 sect	5105-185785	19429	5105-185785	1		
S4	G4-T1	Switch, toggle, dpdt	5106-184341	82389	130312	1		
S5	K1-T2	Switch, toggle, spst	5106-114850	04009	20994-LH	1		
	G4-Q2	Bezel	2401-178962	19429	2401-178962	3		
	H5-Q2	Bezel	2401-178962	19429	2401-178962	REF		
	I5-Q2	Bezel	2401-178962	19429	2401-178962	REF		
	B2-Q1	Ferrule	2404-100420	05704	#300	4		
	B2-T	Ferrule	2404-100420	05704	#300	REF		
	K5-Q1	Ferrule	2404-100420	05704	#300	REF		
	K5-T2	Ferrule	2404-100420	05704	#300	REF		
	B1-R3	Handle	2404-101717	05704	#807	2		
	L1-R3	Handle	2404-101717	05704	#807	REF		
	I5-S1	Holder, pilot lamp	3903-170621	72619	DM910M-66TP	3		
	I3-S1	Holder, pilot lamp	3903-170621	72619	DM910M-66TP	REF		
	H5-S1	Holder, pilot lamp	3903-170621	72619	DM910M-66TP	REF		
	J3-T1	Holder, pilot lamp	3903-153114	13812	162-8430-93i	1		
	D2-R4	Knob, ACCUMULATOR	2405-158956	19429	2405-158956	4		
	C3-T2	Knob, AUDIO	2405-190249	19429	2405-190249	1		
	G4-R1	Knob, FREQUENCY/kHz	2405-170043	19429	2405-170043	3		
	H5-R1	Knob, FREQUENCY/kHz	2405-170043	19429	2405-170043	REF		
	J1-R1	Knob, FREQUENCY/kHz	2405-170043	19429	2405-170043	REF		
	D2-S3	Knob, METER FUNCTION	2405-158956	19429	2405-158956	REF		
	K1-R1	Knob, RF ATTENUATION	2405-170050	19429	2405-170050	2		
	K2-S2	Knob, RF FILTER	2405-158956	19429	2405-158956	REF		
	G4-S2	Knob, TRACKING RATE	2405-158956	19429	2405-158956	REF		
	B3-P5	Panel, front	3156-190751	19429	3156-190751	1		
	G4-Q3	Readout dial, 0-6	2403-188805	19429	2403-188805	1		
	H5-Q3	Readout dial, 0-10	2403-180448	19429	2403-180448	2		
	I5-Q3	Readout dial, 0-10	2403-180448	19429	2403-180448	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A24		**METER FUNCTION SWITCH ASSEMBLY (Not Illustrated)**	5110-191775	19429	5110-191775	REF		
R2		Res, met flm, 76.8Ω ±1%, 1/8w	4705-182949	12400	Type CEA T-O	1		
R3		Res, met flm, 32.4k ±1%, 1/8w	4705-182956	12400	Type CEA T-O	2		
R4		Res, met flm, 32.4k ±1%, 1/8w	4705-182956	12400	Type CEA T-O	REF		
S2		Switch, rotary, 3p, 6 pos, 2 sect	5105-181768	19429	5105-181768	1		
A3		**REAR PANEL ASSEMBLY - Figure 5-4**						
A25	J4-P3	Antenna Selector Assembly (See Figure 5-4)	1702-191635 (207-1-418)	19429	1702-191635	1		
A26	J5-S5	External Recorder Calibrate Assy. (See Figure 5-4)	1702-191643 207-1-419)	19429	1702-191643	1		
F1		Fuse, Type MDL, slow-blow, 1 amp, for 115v or 230v operation (207-4B-, -5B only) (not illustrated)	5101-109272	03614	Type MDL		5	
F2		Fuse, Type MDL, slow-blow, 3/4 amp, for 115v operation (not illustrated)	5101-100256	03614	Type MDL	2	5	
F2		Fuse, Type MDL, slow-blow, 3/8 amp, for 230v operation (not illustrated)	5101-109264	03614	Type MDL	2		
F3		Fuse, Type MDL, slow-blow, 3/4 amp, for 115v operation (not illustrated)	5101-109256	03614	Type MDL	REF		
F3		Fuse, Type MDL, slow-blow, 3/8 amp, for 230v operation (not illustrated)	5101-109264	03614	Type MDL	REF		
J11	C1-U5	Connector, female, Type BNC	2106-152033	02660	UG1094/U	9	2	
J12	C1-U2	Connector, female, Type BNC	2106-152033	02660	UG1094/U	REF		
J13	C1-T4	Connector, female, Type BNC	2106-152033	02660	UG1094/U	REF		
J14	C1-T2	Connector, female, Type BNC	2106-152033	02660	UG1094/U	REF		
J15	C1-S4	Connector, female, Type BNC	2106-152033	02660	UG1094/U	REF		
J16	C1-S1	Connector, female, Type BNC	2106-152033	02660	UG1094/U	REF		
J17	C1-R4	Connector, female, Type BNC (207-4, -5 only)	2106-152033	02660	UG1094/U	REF		
J27	C4-N4	Connector, female, Type BNC (207-4, -5 only)	2106-152033	02660	UG1094/U	REF		
Q1		Transistor, RCA Type 40250 (not illustrated, behind the transistor shield)	4805-183004	95303	Type 40250	REF		
Q2		Transistor, RCA Type 40250 (not illustrated, behind the transistor shield)	4805-183004	95303	Type 40250	REF		

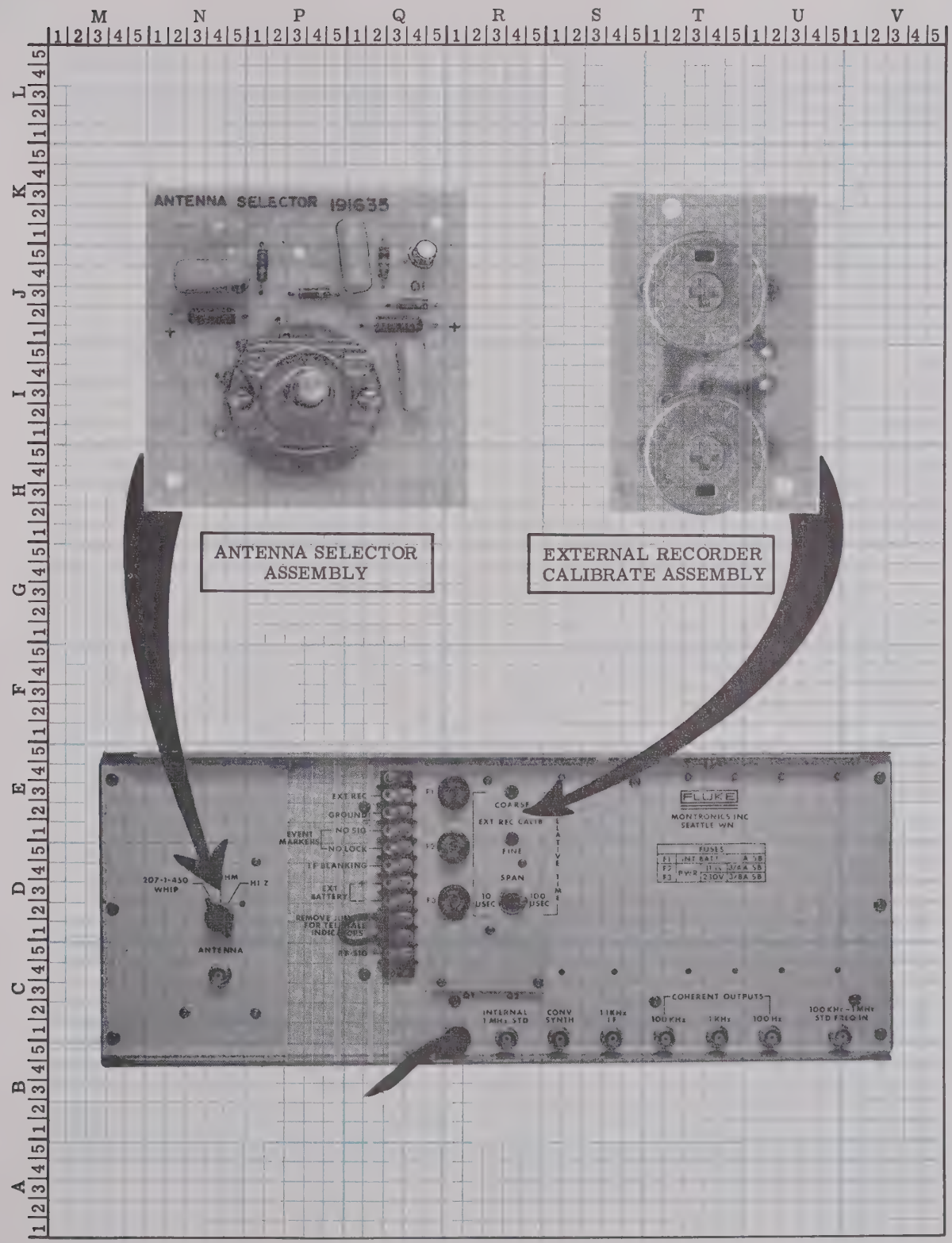


Figure 5-4. REAR PANEL ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R11		Res, comp, 1k ±5%, 1/4w (not illustrated, on J13)	4704-148023	01121	CB1025	36		F
S6	D2-R4	Switch, toggle, spdt	5106-175257	04009	2-1350 EH	1		
TB2	E4-Q3	Barrier strip, 10 pin, feed thru	2815-182774	71785	140	1		
XF1	E3-R1	Fuseholder (207-4B, -5B only)	2102-100107	03614	HKP			
XF2	D5-R1	Fuseholder	2102-100107	03614	HKP	2		
XF3	D2-R1	Fuseholder	2102-100107	03614	HKP	REF		
	D1-P5	Jumper Assembly	6002-191874	19429	6002-191874	1		
	D2-N4	Knob, ANTENNA	2405-170050	19429	2405-170050	REF		
	D1-N1	Panel, rear	3156-190777	19429	3156-190777	1		
		Plug Button, 3/8 inch (207-1, -3 only) (not illustrated)	2109-170118	83330	652	1		
		Plug Button, 1/2 inch (207-1, -3, -4, and -5) (not illustrated	2109-101774	83330	653	1		
	C4-R3	Shield, transistor	3156-190827	19429	3156-190827	1		
	B5-R1	Strain relief	2502-101162	28520	SR-5P-1	1		
A25		**ANTENNA SELECTOR ASSEMBLY Figure 5-4**	1702-191635 (207-1-418)	19429	1702-191635	1		
C1	J5-Q1	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	12		
C2	J2-N4	Cap, Ta, 3.3 uf ±10%, 15v	1508-182808	05397	K3R3C15K	4	1	
C3	J2-Q3	Cap, Ta, 3.3 uf ±10%, 15v	1508-182808	05397	K3R3C15K	REF		
C4	J4-N4	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	REF		
C5	I4-Q4	Cap, mylar, 0.047 uf ±10%, 100v	1507-183269	37942	PVC1147	2		
Q1	J5-Q4	Transistor, Kemet Type F-1047	4805-166223	05397	Type F-1047	2	1	
R1	J5-Q2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R2	J4-P1	Res, comp, 1.5m ±5%, 1/4w	4704-182857	01121	CB1555	2		
R3	J3-P4	Res, comp, 1m ±5%, 1/4w	4704-182204	01121	CB1055	4		
S11	I3-P4	Switch, rotary, 1p, 3 pos, 1 sect	5105-181743	19429	5105-181743	1		
A26		**EXTERNAL RECORDER CALIBRATE ASSEMBLY - Figure 5-4**	1702-191643 (207-1-419)	19429	1702-191643	1		
R43	H5-T2	Res, var, ww, 1.5k ±20%, 2w	4702-183939	71450	Type 115	2		
R47	J3-T2	Res, var, ww, 100Ω ±10%, 2w	4702-183913	71450	Type 115	4		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A4		**PHASE DETECTOR MODULE** Figure 5-5	1702-191460 (207-1-401)	19429	1702-191460	REF		
C1	K1-P5	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	16	2	
C2	K3-Q2	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C3	I4-P2	Cap, Ta, 10 uf ±10%, 20v	1508-160259	12400	TDB248	4	1	
C4	H4-P3	Cap, Ta, 10 uf ±10%, 20v	1508-160259	12400	TDB248	REF		
C5	H5-Q1	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C6	I2-P5	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C7	K3-T3	Cap, elect, 50 uf +75/-10%, 25v	1502-148650	56289	30D506G025-DD4	10	2	
C8	K3-S1	Cap, elect, 50 uf +75/-10%, 25v	1502-148650	56289	30D506G025-DD4	REF		
C9	K1-S3	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C10	K2-R2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C23	D2-S2	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C24	B3-Q2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C25	B5-Q4	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	39	2	
C26	C4-P5	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C27	C4-R5	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C28	D1-S2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C29	C3-R4	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C30	D5-R3	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C31	C1-S5	Cap, elect, 50 uf +75/-10%, 25v	1502-148650	56289	30D506G025-DD4	REF		
C32	D1-Q2	Cap, elect, 50 uf +75/-10%, 25v	1502-148650	56289	30D506G025-DD4	REF		
C33	B4-T2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C34	E1-Q2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
CR1	G4-T1	Diode, Type 1N270	4802-149187	94145	Type 1N270	57	6	
CR2	G4-S5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
P1	E3-U1	Conn, male, 22 contact, chassis mount	2107-149351	95354	MDR-622B	8	1	
Q1	K3-P4	Transistor, Fairchild Type SP-10406	4805-180307	07263	SP-10406	4	1	
Q2	I5-P4	Transistor, Fairchild Type SP-10406	4805-180307	07263	SP-10406	REF		
Q3	I2-Q2	Transistor, Type 2N1306	4805-148825	01295	Type 2N1306	8	1	
Q4	J2-Q2	Transistor, Type 2N1306	4805-148825	01295	Type 2N1306	REF		
Q5	I2-S4	Transistor, Type 2N1306	4805-148825	01295	Type 2N1306	REF		
Q6	I5-S4	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	29	2	
Q7	H3-S2	Transistor, Type 2N1303	4805-148619	01295	Type 2N1303	5	1	
Q8	H4-S4	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q9	I1-R5	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q10	I5-S1	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q11	I4-R2	Transistor, Type 2N1306	4805-148825	01295	Type 2N1306	REF		

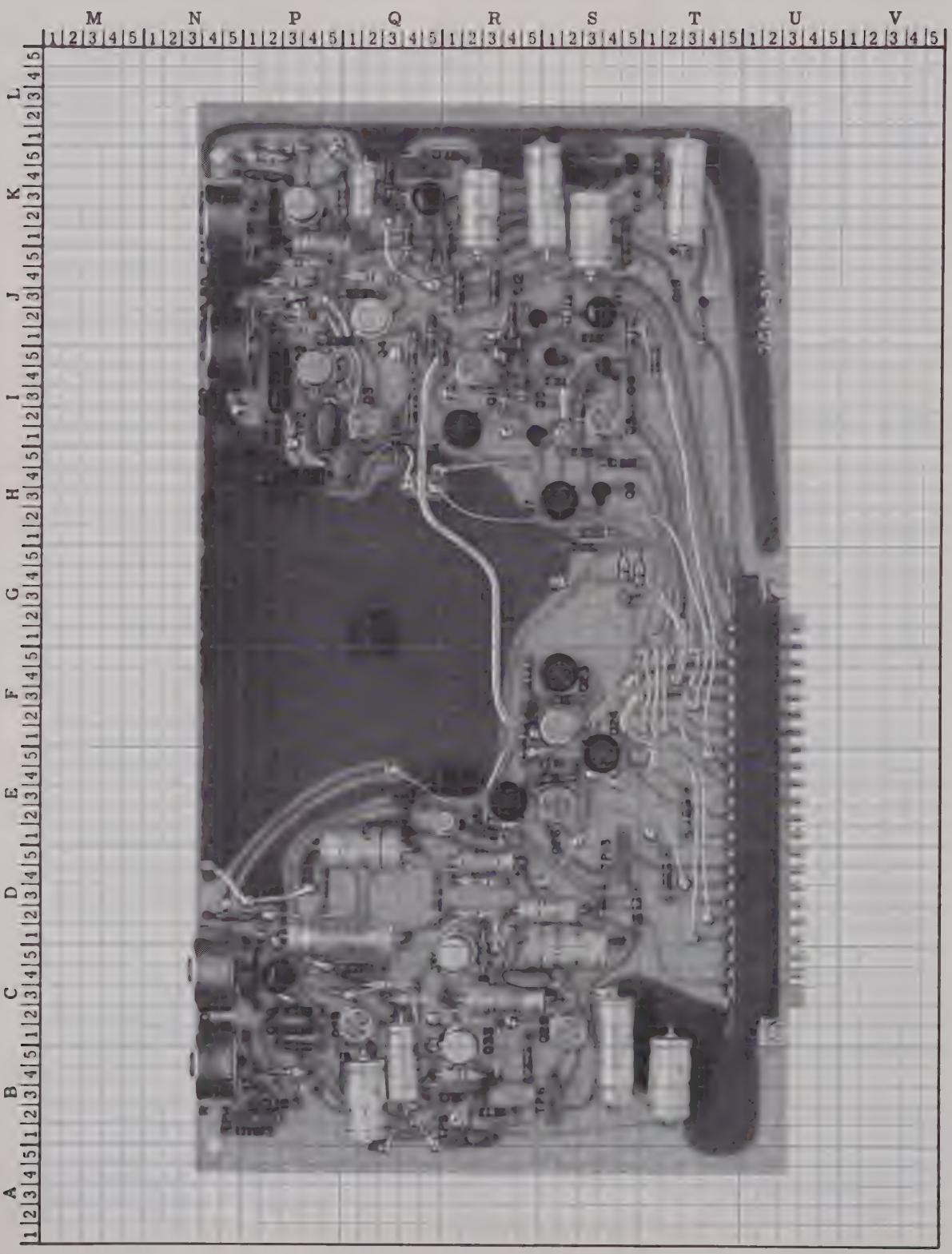


Figure 5-5. PHASE DETECTOR MODULE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q12	J2-R5	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q13	J2-S4	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	32	3	
Q14	I2-R2	Transistor, Type 2N1303	4805-148619	01295	Type 2N1303	REF		
Q15	J4-T4	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	38	3	
Q16	K5-S5	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q17	K3-Q5	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q23	F4-S2	Transistor, Type 2N1303	4805-148619	01295	Type 2N1303	REF		
Q24	E5-S4	Transistor, Type 2N1303	4805-148619	01295	Type 2N1303	REF		
Q25	F2-S2	Transistor, Type 2N1306	4805-148825	01295	Type 2N1306	REF		
Q26	E3-S2	Transistor, Type 2N1306	4805-148825	01295	Type 2N1306	REF		
Q27	E3-R4	Transistor, Type 2N1303	4805-148619	01295	Type 2N1303	REF		
Q28	C2-Q2	Transistor, Type 2N1306	4805-148825	01295	Type 2N1306	REF		
Q29	C1-S2	Transistor, Type 2N1306	4805-148825	01295	Type 2N1306	REF		
Q30	C4-P3	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q31	E3-Q4	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q32	E2-R1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q33	C1-R2	Transistor, Fairchild Type SP-10406	4805-180307	07263	SP-10406	REF		
Q34	C5-R1	Transistor, Fairchild Type SP-10406	4805-180307	07263	SP-10406	REF		
R1	K3-Q1	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	35	2	
R2	J4-P3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R3	K5-P2	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R4	K5-P3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R5	J5-P4	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R6	K2-P2	Res, met flm, 249Ω ±1%, 1/8w	4705-168203	12400	Type CEA T-O	8	1	
R7	K4-P2	Res, met flm, 249Ω ±1%, 1/8w	4705-168203	12400	Type CEA T-O	REF		
R8	K2-N5	Res, var, ww, 10Ω ±10%, 2w	4702-183921	71450	Type 115	2		
R9	J2-P4	Res, met flm, 10k ±1%, 1/8w	4705-168260	12400	Type CEA T-O	5	1	
R10	J3-P3	Res, met flm, 100Ω ±1%, 1/8w	4705-168195	12400	Type CEA T-O	5	1	
R11	J2-P3	Res, met flm, 100Ω ±1%, 1/8w	4705-168195	12400	Type CEA T-O	REF		
R12	J4-Q2	Res, met flm, 10k ±1%, 1/8w	4705-168260	12400	Type CEA T-O	REF		
R13	I1-Q3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R14	I2-Q4	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	13		
R15	I5-Q4	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R16	J3-Q1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	31		
R17	J1-Q1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R18	H5-S5	Res, comp, 22k ±5%, 1/4w	4704-148130	01121	CB2235	3		
R19	H5-S3	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R20	I4-S1	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	30		
R21	I2-S3	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	10		
R22	I4-R4	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R23	I3-R5	Res, comp, 330Ω ±5%, 1/4w	4704-148072	01121	CB3315	REF		
R24	J1-Q5	Res, comp, 22k ±5%, 1/4w	4704-148130	01121	CB2235	REF		
R25	I5-R1	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R26	J1-S5	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R27	J2-R4	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R28	J1-R4	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	15		
R29	J3-S2	Res, comp, 39k ±5%, 1/4w	4704-188466	01121	CB3935	1		
R30	J1-S3	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R31	H1-S4	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R32	K1-S5	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	14		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R33	K4-T1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R34	J5-R1	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	19		
R35	K4-Q3	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	19		
R36	K1-Q4	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R37	J3-R1	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R38	J5-Q5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	48		
R39	J4-R3	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R40	G5-S3	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R55	E2-T3	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	23		
R56	D4-T2	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R57	F1-R5	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R58	F4-R5	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R59	F3-S2	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R60	E5-S1	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R61	B2-R3	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R62	B5-Q1	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R63	B3-R1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R64	B4-R2	Res, met flm, 10k ±1%, 1/8w	4705-168260	12400	Type CEA T-O	REF		
R65	B4-P3	Res, met flm, 100Ω ±1%, 1/8w	4705-168195	12400	Type CEA T-O	REF		
R66	B3-P4	Res, met flm, 100Ω ±1%, 1/8w	4705-168195	12400	Type CEA T-O	REF		
R67	B3-P2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R68	B5-R4	Res, met flm, 10k ±1%, 1/8w	4705-168260	12400	Type CEA T-O	REF		
R69	C4-Q3	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	20	1	
R70	D2-P1	Res, met flm, 249Ω ±1%, 1/8w	4705-168203	12400	Type CEA T-O	REF		
R71	C4-N4	Res, var, ww, 10Ω ±10%, 2w	4702-183921	71450	Type 115	REF		
R72	C4-P1	Res, met flm, 249Ω ±1%, 1/8w	4705-168203	12400	Type CEA T-O	REF		
R73	C3-Q4	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R74	C2-P4	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R75	D4-P5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R76	B5-P4	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R77	C1-P4	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R78	D3-R1	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R79	C4-Q2	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R80	D2-T1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R81	E1-R4	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
R82	D3-S4	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R83	D4-R3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R84	C5-R3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R85	D2-R3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R86	B5-R5	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R87	E4-S1	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R89	J1-T4	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
R90	I5-N5	Res, var, ww, 100Ω ±10%, 2w	4702-183913	71450	Type 115	REF		
R92	B5-N4	Res, var, ww, 100Ω ±10%, 2w	4702-183913	71450	Type 115	REF		
R93	B1-P1	Res, comp, 18k ±5%, 1/4w	4704-148122	01121	CB1835	2		
R94	K5-R1	Res, comp, 18k ±5%, 1/4w	4704-148122	01121	CB1835	REF		
R99	I5-T1	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
TP1	I1-N5	Test point, green	2109-149120	74970	105-0754	20	2	
TP2	I1-P4	Test point, green	2109-149120	74970	105-0754	REF		
TP5	B1-R2	Test point, green	2109-149120	74970	105-0754	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
TP6	B3-S1	Test point, green	2109-149120	74970	105-0754	REF		
TP9	L1-S3	Test point, green	2109-149120	74970	105-0754	REF		
TP10	K4-Q5	Test point, green	2109-149120	74970	105-0754	REF		
TP11	G1-Q2	Test point, black	2109-149112	74970	105-0753	17	2	
TP12	E4-R1	Test point, black	2109-149112	74970	105-10753	REF		
TP13	D5-S5	Test point, green	2109-149120	74970	105-0754	REF		
TP14	B2-P2	Test point, green	2109-149120	74970	105-0753	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-175125	17069	88001	88	6	
A5		**FREQUENCY DIVIDER MODULE Figure 5-6**	1702-191478 (207-1-402)	19429	1702-191478	REF		
C1	F1-R5	Cap, mica, 3,300 pf ±5%, 500v	1504-148320	88419	CD19F332J	2		
C2	I5-U1	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C3	E2-S3	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C4	E1-S4	Cap, mica, 1,800 pf ±5%, 500v	1504-148353	88419	CD19F182J	4		
C5	U3-S4	Cap, mica, 22 pf ±5%, 400v	1504-148551	88419	CD15E220J	7		
C6	D3-T4	Cap, mica, 1,800 pf ±5%, 500v	1504-148353	88419	CD19F182J	REF		
C7	D2-R5	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C8	D3-S2	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C9	K1-R3	Cap, poly, 0.047 uf ±2%, 100v	1507-170449	02799	1PJ473G	3	1	
C10	J4-R3	Cap, mica, 470 pf ±5%, 500v	1504-148429	88419	CD19F471J	2		
C11	J3-R2	Cap, poly, 0.047 uf ±2%, 100v	1507-170449	02799	1PJ473G	REF		
C12	J4-P4	Cap, elect, 50 uf +75/-10%, 25v	1502-148650	56289	30D506G025-DD4	REF		
C13	J2-P2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C14	I3-P3	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C15	I5-P2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C16	G3-S4	Cap, cer, 0.05 uf ±20%, 50v	1401-149161	56289	55C23A1	REF		
C17	F3-T1	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C18	G2-T1	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C19	G4-S2	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C20	C3-R5	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C21	G5-T1	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		G
C22	G3-T4	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		G
CR1	D3-R3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	I1-P3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
K1	G1-R4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	57	5	
K2	G1-R1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K3	F3-R1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K4	C4-Q4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K5	D1-Q2	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K6	D5-Q2	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		

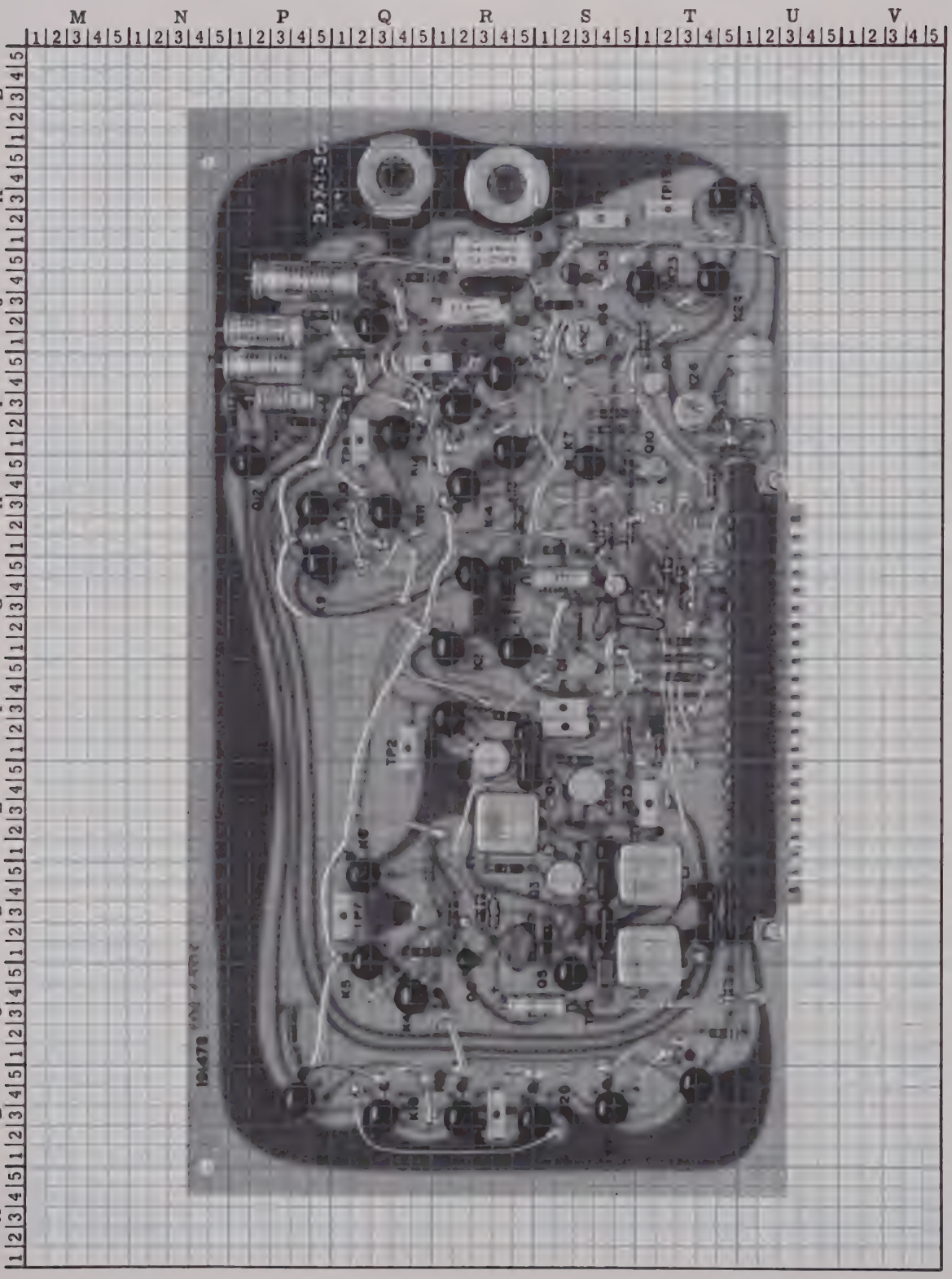


Figure 5-6. FREQUENCY DIVIDER MODULE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
K7	H5-S3	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	19	2	
K8	G5-R2	IC, RTL Flip Flop	4800-183059	19429	4800-183059	REF		
K9	G5-P5	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K10	H3-P4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K11	H3-Q3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K12	I2-Q3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K13	I1-R4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K14	H4-R2	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K15	I5-R3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K16	J1-S3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K17	B4-P4	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K18	B3-Q3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K19	B3-R2	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K20	B3-R5	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K21	B4-S4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K22	B5-T3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K23	J4-T1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K24	J4-T4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K25	K3-T5	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K26	I3-T3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K27	I3-R1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
L1	D5-T1	Inductor, var, 0.015 uh	1800-171488	19429	1800-171488	6	1	
L2	K4-R4	Inductor, var, 5.4 mh	1800-191981	19429	1800-191981	1	1	
P2	F4-U1	Connector, male, 22 contact, chassis mount	2107-149351	59354	MDR-622B	REF		
Q1	F5-S3	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q2	F1-R3	Transistor, Type 2N1177	4805-168302	95303	Type 2N1177	8	1	
Q3	D5-S2	Transistor, Type 2N1177	4805-168302	95303	Type 2N1177	REF		
Q4	E4-S3	Transistor, Type 2N1177	4805-168302	95303	Type 2N1177	REF		
Q5	C5-S2	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q6	D1-R2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		E
Q6	D1-R2	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	12	1	F
Q7	D3-Q5	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q8	G4-S4	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q9	J2-Q2	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q10	H5-T1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q11	I4-T1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q12	H5-P1	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q13	J4-S2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
R1	G1-T2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R2	G2-S3	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R3	F3-R4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R4	E4-S5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R5	D5-R4	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R6	F1-T2	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R7	F1-S5	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R8	F5-T3	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R9	D2-R5	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R10	D2-S1	Res, comp, 68Ω ±5%, 1/4w	4704-147918	01121	CB6805	4		
R11	D2-S3	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R12	D3-R3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R13	D3-A2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R14	D1-Q5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R15	D5-Q5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R16	H1-S5	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R17	H1-S4	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R18	F1-S3	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R19	H2-R5	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R20	G5-T2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R21	H1-S3	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R22	G4-T3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R23	H1-S2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R24	I3-S4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R25	I2-S4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R26	H5-S5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R27	J1-T1	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R28	H4-T4	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		E
R28	H4-T4	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		F
R29	J3-S2	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R30	J4-Q5	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R31	I2-P4	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R32	J2-P5	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R33	I5-Q2	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R34	I3-Q1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R35	I3-P1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R36	C2-P4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R38	C4-T5	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
R39	G1-T3	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R40	C2-T5	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
R41	H2-T3	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R42	I1-T5	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R44	E4-S4	Res, comp, 33k ±5%, 1/4w	4704-148155	01121	CB3335	5		
T1	E2-R4	Transformer, var	1800-163964	19429	1800-163964	1	1	
T2	D1-T1	Transformer, var	1800-171488	19429	1800-171488	REF		
T3	K4-Q4	Transformer, var	1800-191999	19429	1800-191999	1	1	
TP1	F3-S2	Test point, yellow	2109-149138	74970	105-0757	35	2	
TP2	F1-Q4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP3	F2-S2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP4	E3-T1	Test point, yellow	2109-149138	74970	105-0757	REF		
TP5	C4-S4	Test point, green	2109-149120	74970	105-0754	REF		
TP6	G4-R4	Test point, black	2109-149112	74970	105-0753	REF		
TP7	D3-Q1	Test point, yellow	2109-149138	74970	105-0757	REF		
TP8	I1-Q2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP9	I5-Q5	Test point, yellow	2109-149138	74970	105-0757	REF		
TP10	K2-S4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP11	I5-Q5	Test point, green	2109-149120	74970	105-0754	REF		
TP12	B3-R4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP13	K3-T2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP14	F1-P2	Test point, black	2109-149112	74970	105-0753	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-152207	17069	88001	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A6		**PHASE SHIFTER MODULE** Figure 5-7	1702-191486 (207-1-403)	19429	1702-191486	REF		
C1	G2-T3	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C2	G1-R5	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C3	E5-R3	Cap, mica, 22 pf ±5%, 500v	1504-148551	88419	CD15E220J	REF		
C4	H3-T2	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C5	H1-S5	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C6	C4-T2	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C7	E5-S5	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C8	D2-R2	Cap, mica, 47 pf ±5%, 500v	1504-148536	88419	CD15E470J	3		
C9	D5-R3	Cap, mica, 1,000 pf ±5%, 500v	1504-148387	88419	CD19F102J	6		
C10	E2-S5	Cap, mica, 22 pf ±5%, 500v	1504-148551	88419	CD15E220J	REF		
C11	C3-T1	Cap, mica, 2,200 pf ±5%, 500v	1504-148346	88419	CD19F222J	2		
C12	D2-T2	Cap, mica, 33 pf ±5%, 500v	1504-160317	88419	CD15F330J	3		
C13	C5-T3	Cap, mica, 2,200 pf ±5%, 500v	1504-148346	88419	CD19F222J	REF		
C14	C2-S1	Cap, mica, 1,800 pf ±5%, 500v	1504-148353	88419	CD19F182J	REF		
C15	C5-R3	Cap, mica, 33 pf ±5%, 500v	1504-160317	88419	CD15F330J	REF		
C16	C4-R1	Cap, mica, 1,800 pf ±5%, 500v	1504-148353	88419	CD19F182J	REF		
C17	D2-P5	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C18	D5-Q2	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C19	D5-Q4	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C20	E4-Q1	Cap, mica, 68 pf ±5%, 500v	1504-148510	88419	CD15F680J	1		
C21	H5-S3	Cap, Ta, 10 uf ±10%, 20v	1508-160259	12400	TDB248	REF		
C22	I5-T2	Cap, Ta, 10 uf ±10%, 20v	1508-160259	12400	TDB248	REF		
C23	J3-P4	Cap, Ta, 33 uf ±10%, 10v	1508-182832	12400	TDB364	2	1	
C24	J4-Q5	Cap, mica, 22 pf ±5%, 500v	1504-148551	88419	CD15E220J	REF		
C25	J4-R1	Cap, mica, 22 pf ±5%, 500v	1504-148551	88419	CD15E220J	REF		
C26	J2-S1	Cap, mica, 330 pf ±5%, 500v	1504-148445	88419	CD15F331J	3		
C27	J3-T1	Cap, Ta, 33 uf ±10%, 10v	1508-182832	12400	TDB364	REF		
C28	J5-T2	Cap, mica, 22 pf ±5%, 500v	1504-148551	88419	CD15E220J	REF		
C29	F2-T4	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C30	F5-T4	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C31	G3-R4	Cap, mica, 1,000 pf ±5%, 500v	1504-148387	88419	CD19F102J	REF		
C32	I3-S3	Cap, mica, 1,000 pf ±5%, 500v	1504-148387	88419	CD19F102J	REF		
C33	K3-U1	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C34	K2-T4	Cap, mica, 22 pf ±5%, 500v	1504-148551	88419	CD15E220J	REF		
CR1	F4-S4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	F3-S4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR3	G1-R3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR4	F2-S2	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR5	D4-R5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR6	E3-Q4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR7	I3-R1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR8	J5-R5	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	16	2	
CR9	K2-R5	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR10	K3-R5	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		

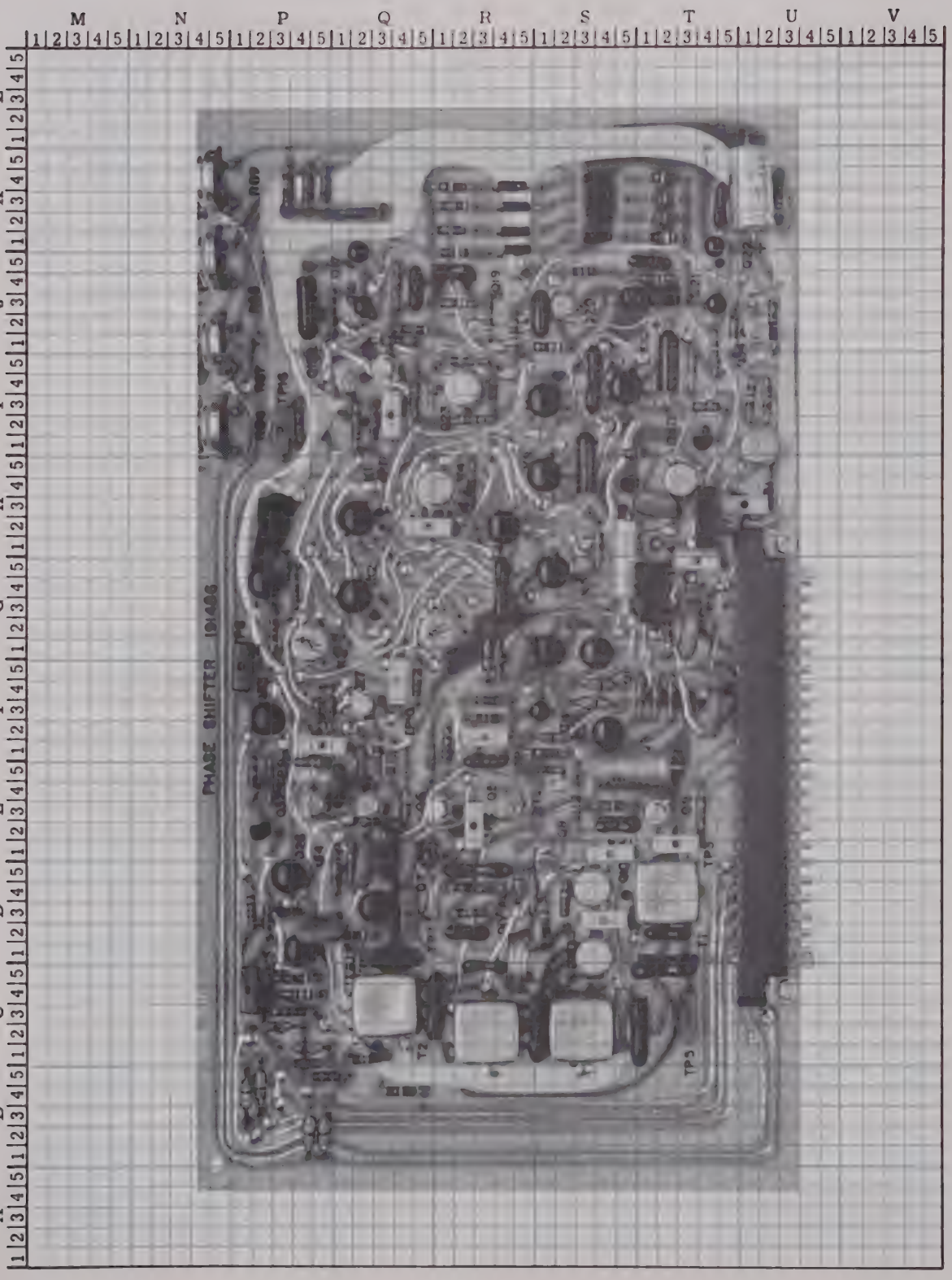


Figure 5-7. PHASE SHIFTER MODULE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR11	K4-R5	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR12	K1-S4	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR13	K2-S4	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR14	K3-S4	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR15	K4-S4	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR16	B4-P1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR17	B4-P2	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR18	C1-P4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR19	B2-P4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR20	C2-P3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR21	B2-P5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR22	G4-T1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		C
CR22	G4-T1	Diode, factory selected	[1]				1	D
CR23	H2-T4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		C
CR23	H2-T4	Diode, factory selected	[1]					D
K1	H2-Q2	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K2	G3-Q2	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K3	G1-P5	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K4	H4-R1	IC, RTL Dual 3-Input Gate	4800-183046	07263	915	2	1	
K5	G5-S2	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K6	G2-R1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K7	H2-R4	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K8	I3-S1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K9	H5-S1	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K10	I4-S5	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
L1	C2-S3	Inductor, var, 0.015 uh	1800-171488	19429	1800-171488	REF		
L2	C2-R3	Inductor, var, 0.015 uh	1800-171488	19429	1800-171488	REF		
P3	E4-U2	Connector, male, 22 contact, chassis mount	2107-149351	95354	MDR-622B	REF		
Q1	G1-S4	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q2	G1-S1	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q3	F2-S4	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q4	F3-S1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		E
Q4	F3-S1	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		F
Q5	E3-R5	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q6	E3-R1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q7	E1-R1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		E
Q7	E1-R1	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		F
Q8	D5-S1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q9	E3-T2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q10	D4-S4	Transistor, Type 2N1177	4805-168302	95303	Type 2N1177	REF		
Q11	D1-S4	Transistor, Type 2N1177	4805-168302	95303	Type 2N1177	REF		
Q12	D3-Q3	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q13	E3-Q3	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q14	E3-P5	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q15	I4-Q1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q16	I5-Q3	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q17	J5-Q2	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		
Q18	J3-Q2	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		
Q20	J3-S2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q21	J3-T4	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		
Q22	K1-T4	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		
Q23	I4-R2	Transistor, Type 2N1177	4805-168302	95303	Type 2N1177	REF		
Q24	G4-P2	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q25	D1-P4	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q26	D5-P3	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q27	F3-Q2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q28	H4-S5	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q29	H4-T3	Transistor, Type 2N3945	4805-203489	03877	Type 2N3945	2	1	
Q30	I1-T4	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q31	I1-U2	Transistor, Type 2N3945	4805-203489	03877	Type 2N3945	REF		
Q32	E2-P2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q33	F3-P2	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q34	J2-U2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
R1	G2-T2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R2	G2-S3	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R3	F3-T2	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R4	F4-T1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R5	F4-T2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R6	F5-R4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R7	F4-R3	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R8	F2-R3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R9	F1-S1	Res, comp, 820Ω ±5%, 1/4w	4704-148015	01121	CB8215	1		
R10	F1-Q5	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R11	F1-R1	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R12	E3-S1	Res, comp, 68k ±5%, 1/4w	4704-148171	01121	CB6835	5		
R13	D4-R2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R14	D3-R3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R15	D1-R5	Res, var, 5k	4701-183103	37943	MTC53L1	2		E
R15	D1-R5	Res, var, 1.5k	4701-183087	37943	MTC152L1	2		F
R16	D4-R5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		E
R16	D4-R5	Res, 12.7k, factory selected	(2)					F
R17	D3-S1	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R18	E3-S5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R19	E3-S3	Res, comp, 68k ±5%, 1/4w	4704-148171	01121	CB6835	REF		
R20	E3-T4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R21	D4-S2	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R22	D1-S2	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R23	C5-Q1	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
R24	D2-Q2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R25	E1-Q2	Res, comp, 22Ω ±5%, 1/4w	4702-147884	01121	CB2205	3		
R26	D5-Q1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R27	E5-Q4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R28	E1-Q3	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R29	F1-Q3	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R30	F1-Q2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R31	E5-P4	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R32	F4-Q5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R33	F3-Q1	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R34	E5-S1	Res, comp, 150Ω ±5%, 1/4w	4704-147934	01121	CB1515	1		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R35	C1-P5	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R36	B5-P5	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R37	B4-Q4	Res, comp, 100k ±5%, 1/4w	4704-148189	01121	CB1045	3		
R38	C1-Q2	Res, comp, 100k ±5%, 1/4w	4704-148189	01121	CB1045	REF		
R39	E5-P3	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R40	D3-P3	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R41	I1-T1	Res, comp, 180Ω ±5%, 1/4w	4704-147942	01121	CB1815	REF		
R42	D4-P1	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R43	E5-P2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R44	G2-P3	Res, comp, 47k ±5%, 1/4w	4704-148163	01121	CB4735	6		
R45	G4-P4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R46	C3-P4	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R47	C5-P4	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R48	C4-P4	Res, comp, 47k ±5%, 1/4w	4704-148163	01121	CB4735	REF		
R49	F3-P5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R50	H1-S4	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R51	I3-U1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R52	I3-T4	Res, comp, 180Ω ±5%, 1/4w	4704-147942	01121	CB1815	REF		
R53	I5-T3	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R54	I3-U2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R55	I2-P4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R56	I4-R4	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R57	I2-Q3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R58	I5-R2	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R59	I2-R3	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
R60	I4-R4	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R61	I2-Q2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R62	I2-Q3	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R63	J1-Q4	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R64	J5-R2	Res, comp, 3.9k ±5%, 1/4w	4704-148064	01121	CB3925	REF		
R65	K2-R2	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R66	K3-R2	Res, comp, 47k ±5%, 1/4w	4704-148163	01121	CB4735	REF		
R67	K4-R2	Res, comp, 150k ±5%, 1/4w	4704-182212	01121	CB1545	1		
R68	J2-Q5	Res, comp, 47k ±5%, 1/4w	4704-148163	01121	CB4735	REF		
R69	J4-Q4	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R70	J3-Q1	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R71	J3-R2	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R72	J2-R5	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R73	J2-R3	Res, comp, 47k ±5%, 1/4w	4704-148163	01121	CB4735	REF		
R74	J5-S3	Res, comp, 68k ±5%, 1/4w	4704-148171	01121	CB6835	REF		
R75	J1-S1	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R76	K1-T2	Res, comp, 3.9k ±5%, 1/4w	4704-148064	01121	CB3925	REF		
R77	K2-T2	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R78	K3-T2	Res, comp, 47k ±5%, 1/4w	4704-148163	01121	CB4735	REF		
R79	K4-T2	Res, comp, 150k ±5%, 1/4w	4704-182212	01121	CB1545	REF		
R80	K2-Q2	Res, comp, 1M ±5%, 1/4w	4704-182204	01121	CB1055	REF		A
R80	K2-Q2	Res, comp, 10M ±5%, 1/4w	4704-194944	01121	CB1065	4		B
R81	K4-P5	Res, comp, 1M ±5%, 1/4w	4704-182204	01121	CB1055	REF		A
R81	K4-P5	Res, comp, 10M ±5%, 1/4w	4704-194944	01121	CB1065	REF		B
R82	K4-P4	Res, comp, 10M ±5%, 1/4w	4704-194944	01121	CB1065	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R83	K4-P3	Res, comp, 10k ±5%, 1/4w	4704-194944	01121	CB1065	REF		
R84	J4-T1	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R85	I5-T4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R86	I2-N5	Res, var, 1.5k	4701-183087	37943	MTC152L1	REF		
R87	J1-N5	Res, var, 5k	4701-183103	37943	MTC53L1	REF		
R88	J5-N4	Res, var, 15k	4701-183079	37943	MTC153L1	9	1	
R89	K4-N4	Res, var, 50k	4701-183095	37943	MTC54L1	5	1	
R90	J2-T5	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R91	K3-U3	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R92	J2-U2	Res, comp, 68k ±5%, 1/4w	4704-148171	01121	CB6835	REF		
R110	G3-T4	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
T1	D4-T2	Transformer, var	1800-171488	19429	1800-171488	REF		
T2	C3-Q3	Transformer, var	1800-171488	19429	1800-171488	REF		
TP1	F2-R2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP2	E2-R3	Test point, yellow	2109-149138	74970	105-0757	REF		
TP3	E1-T3	Test point, yellow	2109-149138	74970	105-0757	REF		
TP4	E1-S4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP5	C3-T3	Test point, green	2109-149120	74970	105-0754	REF		
TP6	D3-S4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP7	D3-Q5	Test point, green	2109-149120	74970	105-0754	REF		
TP8	F5-P1	Test point, green	2109-149120	74970	105-0754	REF		
TP9	F1-P5	Test point, yellow	2109-149138	74970	105-0757	REF		
TP10	F4-Q4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP11	D1-Q4	Test point, black	2109-149112	74970	105-0753	REF		
TP12	H2-P2	Test point, black	2109-149112	74970	105-0753	REF		
TP13	C4-P2	Test point, green	2109-149120	74970	105-0754	REF		
TP14	G5-T4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP15	H3-U1	Test point, yellow	2109-149138	74970	105-0757	REF		
TP16	I2-P3	Test point, red	2109-170480	74970	105-0752	1	1	
TP17	I2-Q4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP18	H2-Q5	Test point, yellow	2109-149138	74970	105-0757	REF		
		Transipad TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		

1> These components are factory matched. If replacement is required, order complete set, part number 4807-203497.

2> This resistor is factory selected. If replacement is required replace with same value.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A7		**READOUT MODULE - Figure 5-8**	1702-191494 (207-1-404)	19429	1702-191494	REF		
C1	G5-S3	Cap, cer, 0.05 uf ±20%, 50v (207-3, -5 only)	1501-149161	56289	55C23A1			
C2	H2-P5	Cap, cer, 0.05 uf ±20%, 50v (207-3, -5 only)	1501-149161	56289	55C23A1			
C3	G5-P3	Cap, elect, 20 uf +75/-10%, 25v (207-3, -5 only)	1502-148817	56289	30D206G025-DB4			
C4	G5-P1	Cap, cer, 0.05 uf ±20%, 50v (207-3, -5 only)	1501-149161	56289	55C23A1			
C5	G5-Q2	Cap, mica, 22 pf ±5%, 500v (207-3, -5 only)	1504-148551	88419	CD15E220J			
C6	D5-Q1	Cap, cer, 0.05 uf ±20%, 50v (207-3, -5 only)	1501-149161	56289	55C23A1			
C7	D5-Q1	Cap, elect, 20 uf +75/-10%, 25v (207-3, -5 only)	1502-148817	56289	30D206G025-DB4			
C8	F3-P5	Cap, mica, 22 pf ±5%, 500v (207-3, -5 only)	1504-148551	88419	CD15E220J			
C9	F4-Q2	Cap, mica, 1,000 pf ±5%, 500v (207-3, -5 only)	1504-148387	88419	CD19F102J			
C10	E3-Q3	Cap, mica, 22 pf ±5%, 500v (207-3, -5 only)	1504-148551	88419	CD15E220J			
C11	G5-S3	Cap, mica, 47 pf ±5%, 500v	1504-148536	88419	CD15E470J	REF		
C12	E1-R2	Cap, cer, 0.05 uf ±20%, 50v (207-3, -5 only)	1501-149161	88419	55C23A1			
C13	J1-P2	Cap, elect, 50 uf +75/-10%, 25v	1502-148650	56289	30D506G025-DD4	REF		
C14	K1-R4	Cap, elect, 50 uf +75/-10%, 6v	1502-187641	56289	30D506G006-CB4	REF		
C15	K5-Q3	Cap, elect, 50 uf +75/-10%, 6v	1502-187641	56289	30D506G006-CB4	REF		
C16	K2-Q3	Cap, elect, 50 uf +75/-10%, 6v	1502-187641	56289	30D506G006-CB4	REF		
C17	J2-Q3	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C18	F3-T3	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C19	F4-T3	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C20	I3-T1	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
CR1	H1-Q3	Diode, Type 1N270 (207-3, -5 only)	4802-149187	94145	Type 1N270			
CR2	H2-Q3	Diode, Type 1N270 (207-3, -5 only)	4802-149187	94145	Type 1N270			
CR3	F2-R1	Diode, Type 1N270 (207-3, -5 only)	4802-149187	94145	Type 1N270			
CR4	G5-R1	Diode, Type 1N270 (207-3, -5 only)	4802-149187	94145	Type 1N270			
CR5	H2-R1	Diode, Type 1N270 (207-3, -5 only)	4802-149187	94145	Type 1N270			
CR6	K2-P2	Diode, Type 1N4148	4802-203323	89732	Type 1N4148	REF		
CR7	J4-Q2	Diode, zener, 6.3v, Type 1N3496	4803-172148	03877	Type 1N3496	1	1	

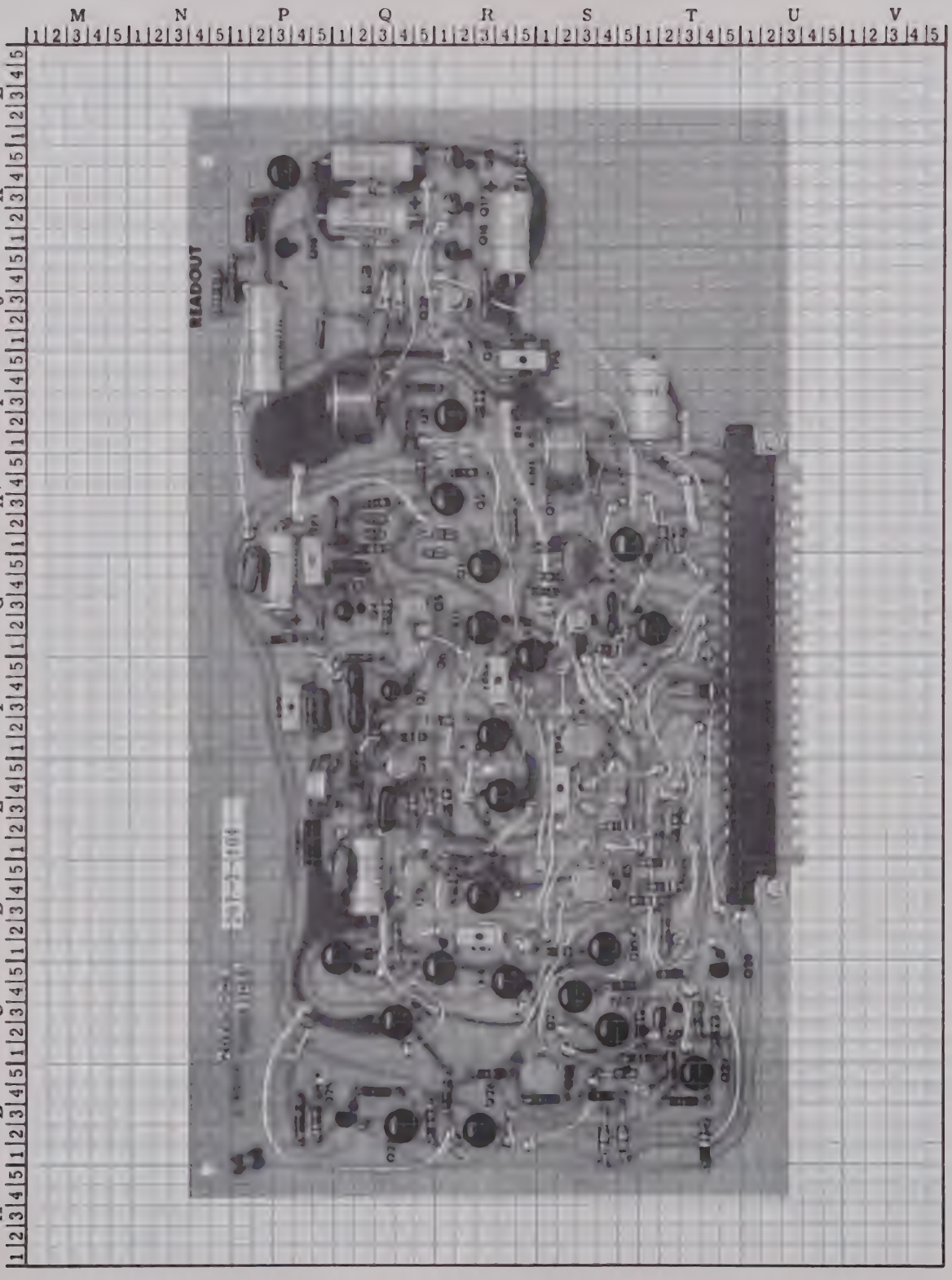


Figure 5-8. READOUT MODULE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR8	B5-S5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR9	B2-S4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR10	B2-S5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR11	H1-T2	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR12	H1-T3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
K1	G2-R3	IC, RTL Flip Flop (207-3, -5 only)	4800-183053	19429	4800-183053			
K2	C2-Q4	IC, RTL Flip Flop (207-3, -5 only)	4800-183053	19429	4800-183053			
K3	C5-R1	IC, RTL Flip Flop (207-3, -5 only)	4800-183053	19429	4800-183053			
K4	C4-R4	IC, RTL Flip Flop (207-3, -5 only)	4800-183053	19429	4800-183053			
K5	D4-S3	IC, RTL Dual 3-Input Gate (207-3, -5 only)	4800-183046	07263	915			
K6	F1-S3	IC, RTL Dual 3-Input Gate	4800-183046	07263	915	REF		
K7	G2-T1	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K8	H1-S5	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K9	E4-R4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K10	F2-R4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K11	G2-R3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K12	G1-R5	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
P4	U2-F4	Connector, male, 22 contact (not illustrated	2107-149351	95354	MDR-622B	REF		
Q1	G5-R3	Transistor, Type 2N3643 (207-3, -5 only)	4805-182196	01295	Type 2N3643			
Q2	H3-R1	Transistor, Type 2N3643 (207-3, -5 only)	4805-182196	01295	Type 2N3643			
Q3	I2-R1	Transistor, Type 2N3643 (207-3, -5 only)	4805-182196	01295	Type 2N3643			
Q4	G3-Q1	Transistor, Type 2N706A (207-3, -5 only)	4805-148593	01295	Type 2N706A			E
Q4	G3-Q1	Transistor, C. D. Type CH23030 (207-3, -5 only)	4805-159855	07910	Type CH23030			F
Q5	G3-Q5	Transistor, Type 2N706A (207-3, -5 only)	4805-148593	01295	Type 2N706A			
Q6	G1-Q5	Transistor, Type 2N706A (207-3, -5 only)	4805-148593	01295	Type 2N706A			
Q7	F4-Q3	Transistor, Type 2N706A (207-3, -5 only)	4805-148593	01295	Type 2N706A			
Q8	E5-Q4	Transistor, Type 2N706A (207-3, -5 only)	4805-148593	01295	Type 2N706A			
Q9	D5-Q5	Transistor, Type 2N706A (207-3, -5 only)	4805-148593	01295	Type 2N706A			
Q10	D1-S4	Transistor, Type 2N3643 (207-3, -5 only)	4805-182196	01295	Type 2N3643			
Q11	D4-R3	Transistor, Type 2N3643 (207-3, -5 only)	4805-182196	01295	Type 2N3643			
Q12	G2-S3	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q13	H2-S2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q14	K4-P3	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q15	K5-R2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q16	J5-P3	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q17	K3-R2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q18	J5-R2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q19	I5-R2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q20	J3-R1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q21	C4-S3	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q22	B5-S1	Transistor, Type 2N696	4805-148601	01295	Type 2N696	9	1	
Q23	C3-T2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q24	C2-S4	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q25	B3-Q1	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q26	B2-R3	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q27	B2-Q4	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q28	C5-T5	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q29	B5-T4	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
R1	H1-S1	Res, comp, 4.7k ±5%, 1/4w (207-3, -5 only)	4704-148072	01121	CB4725			
R2	H5-R2	Res, comp, 1.5k ±5%, 1/4w (207-3, -5 only)	4704-148031	01121	CB1525			
R3	I4-Q5	Res, comp, 1k ±5%, 1/4w (207-3, -5 only)	4704-148023	01121	CB1025			
R4	I2-Q4	Res, comp, 10k ±5%, 1/4w (207-3, -5 only)	4704-148106	01121	CB1035			
R5	I3-R3	Res, comp, 10k ±5%, 1/4w (207-3, -5 only)	4704-148106	01121	CB1035			
R6	G1-P3	Res, comp, 220Ω ±5%, 1/4w (207-3, -5 only)	4704-147959	01121	CB2215			
R7	G2-P5	Res, comp, 1k ±5%, 1/4w (207-3, -5 only)	4704-148023	01121	CB1025			
R8	G4-Q1	Res, comp, 10k ±5%, 1/4w (207-3, -5 only)	4704-148106	01121	CB1035			
R9	H3-Q3	Res, comp, 820Ω ±5%, 1/4w (207-3, -5 only)	4704-148015	01121	CB8215			
R10	H4-Q5	Res, comp, 150Ω ±5%, 1/4w (207-3, -5 only)	4704-147934	01121	CB1515			
R11	G4-Q2	Res, comp, 10k ±5%, 1/4w (207-3, -5 only)	4704-148106	01121	CB1035			
R12	G3-Q3	Res, comp, 68k ±5%, 1/4w (207-3, -5 only)	4704-148171	01121	CB6835			
R13	F2-Q3	Res, comp, 4.7k ±5%, 1/4w (207-3, -5 only)	4704-148072	01121	CB4725			
R14	E4-P5	Res, var, 5k (207-3, -5 only)	4701-183103	37942	MTC53L1			E
R14	E4-P5	Res, var, 1.5k (207-3, -5 only)	4701-183087	37942	MTC152L1			F

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R15	E4-Q2	Res, comp, 10k ±5%, 1/4w (207-3, -5 only)	4704-148106	01121	CB1035			E
R15	E4-Q2	Res, 12.7k, factory selected (207-3, -5 only)	1					F
R16	E5-Q2	Res, comp, 1k ±5%, 1/4w (207-3, -5 only)	4704-148023	01121	CB1025			
R17	E3-Q5	Res, comp, 10k ±5%, 1/4w (207-3, -5 only)	4704-148106	01121	CB1035			
R18	F1-Q5	Res, comp, 68k ±5%, 1/4w (207-3, -5 only)	4704-148171	01121	CB6835			
R19	F3-P5	Res, comp, 10k ±5%, 1/4w (207-3, -5 only)	4704-148106	01121	CB1035			
R20	D1-Q4	Res, comp, 470Ω ±5%, 1/4w (207-3, -5 only)	4704-147983	01121	CB4715			
R21	E2-T2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R22	E2-T3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R23	D4-T2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R24	D5-T2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R25	E4-Q5	Res, comp, 3.3k ±5%, 1/4w (207-3, -5 only)	4704-148056	01121	CB3325			
R26	D1-S2	Res, comp, 10k ±5%, 1/4w (207-3, -5 only)	4704-148106	01121	CB1035			
R27	D4-R2	Res, comp, 68k ±5%, 1/4w (207-3, -5 only)	4704-148171	01121	CB6835			
R28	E3-R1	Res, comp, 100k ±5%, 1/4w (207-3, -5 only)	4704-148189	01121	CB1045			
R29	E2-S5	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R31	D5-R3	Res, comp, 3.3k ±5%, 1/4w (207-3, -5 only)	4704-148056	01121	CB3325			
R32	D3-T1	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R33	G1-S4	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R34	G4-S2	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R35	G3-S1	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R36	H2-R5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R37	J4-P1	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R38	K4-R5	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R39	J3-R3	Res, comp, 1.5k ±5%, 1/4w	4704-148039	01121	CB1525	1		
R40	J3-N5	Res, comp, 33Ω ±5%, 1/4w	4704-175034	01121	CB3305	1		
R41	J1-P5	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R42	J3-Q4	Res, met flm, 1k ±1%, 1/8w	4705-168229	12400	Type CEA T-O	7	1	
R43	I3-Q2	Res, var, ww, 1.5k ±20%, 2w	4702-183939	71450	Type 115	REF		
R44	K3-Q2	Res, met flm, 249Ω ±1%, 1/8w	4705-168203	12400	Type CEA T-O	REF		
R45	J3-Q3	Res, met flm, 1k ±1%, 1/8w	4705-168229	12400	Type CEA T-O	REF		
R46	K1-Q2	Res, met flm, 249Ω ±1%, 1/8w	4705-168203	12400	Type CEA T-O	REF		
R47	H5-S2	Res, var, ww, 100Ω ±10%, 2w	4702-183913	71450	Type 115	REF		
R48	I4-R5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R49	J1-R5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R50	D2-T2	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R51	C4-S5	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R53	B5-R3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R55	B4-S1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R56	B4-S4	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R57	C2-T1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R58	C1-T1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R59	C5-T2	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R60	B3-P5	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R61	B4-R1	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R62	B3-P4	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R63	B4-Q3	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R65	B2-Q5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R66	B1-T4	Res, comp, 100k ±5%, 1/4w	4704-148189	01121	CB1045	REF		
R67	C2-T5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R68	B5-T2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R69	B4-T3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R70	C3-T4	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
TP1	G5-P5	Test point, yellow (207-3, -5 only)	2109-149138	74970	105-0757			
TP2	F3-P3	Test point, yellow (207-3, -5 only)	2109-149138	74970	105-0757			
TP3	D2-R3	Test point, yellow (207-3, -5 only)	2109-149138	74970	105-0757			
TP4	E4-S2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP5	F4-R4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP6	I5-R5	Test point, yellow	2109-149138	74970	105-0757	REF		
TP7	E1-P5	Test point, black	2109-149112	74970	105-0752	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		

1 This resistor is factory selected. If replacement is required, replace with exact value.

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A8		**IF AMPLIFIER MODULE - Figure 5-9**	1702-191502 (207-1-405)	19429	1702-191502	REF		
C1	I5-N5	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C2	I5-Q2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C3	J3-P2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C4	J3-P4	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C5	K1-Q4	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C6	C2-P3	Cap, elect, 50 uf +75/-10%, 25v	1502-148650	56289	30D506G025-DD4	REF		
C7	D3-P1	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73449	C426ARE125	REF		
C8	D4-Q4	Cap, mylar, 0.01 uf +75/-10%, 200v	1507-168450	37942	PVC211	REF		
C9	D1-P1	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73449	C426ARE125	REF		
C10	E2-R1	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C11	E4-S2	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C12	F1-R2	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C13	E2-P2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73449	C426ARE125	REF		
C15	E5-P2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73449	C426ARE125	REF		
C16	F3-Q4	Cap, mylar, 0.01 uf +75/-10%, 200v	1507-168450	37942	PVC211	REF		
C17	F3-P5	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C18	F3-P3	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C19	G3-P2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73449	C426ARE125	REF		
C20	G3-N5	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73449	C426ARE125	REF		
C21	E4-S4	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C22	E1-T2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C23	F5-R2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C24	G3-R4	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C25	E4-S5	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C26	C4-T2	Cap, plstc, 0.1 uf ±2%, 100v	1504-188706	02799	1PJ104G	4	1	
C27	C3-R5	Cap, plstc, 0.1 uf ±2%, 100v	1507-188706	02799	1PJ104G	REF		
C28	C4-S5	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C29	C4-S3	Cap, plstc, 0.1 uf ±2%, 100v	1507-188706	02799	1PJ104G	REF		
C30	B3-P4	Cap, plstc, 0.1 uf ±2%, 100v	1507-188706	02799	1PJ104G	REF		
C31	C2-R3	Cap, mylar, 0.0047 uf ±20%, 200v	1507-106054	56289	47202	2		
C32	H2-Q3	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73449	C426ARE125	REF		
C33	F5-T2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73449	C426ARE125	REF		

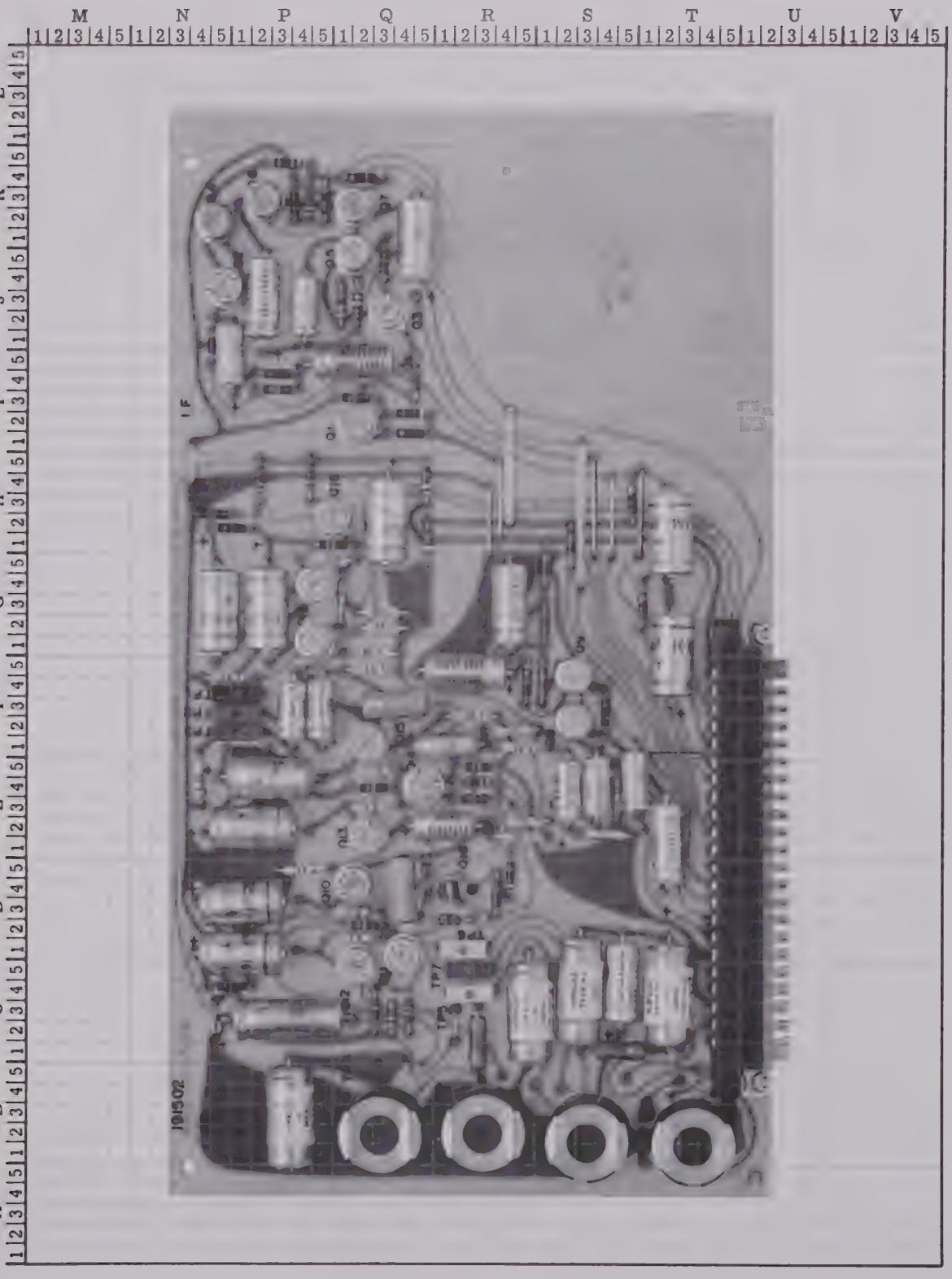


Figure 5-9. IF AMPLIFIER MODULE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C34	H2-T2	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73449	C426ARE125	REF		
C35	C1-S5	Cap, mylar, 0.0047 uf ±20%, 200v	1507-106054	56289	47202	REF		
CR1	D3-R1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	D5-Q5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
L1	B1-T3	Inductor, var, 210 mh	1800-192047	19429	1800-192047	4	1	
L2	B1-S3	Inductor, var, 210 mh	1800-192047	19429	1800-192047	REF		
L3	B1-R3	Inductor, var, 210 mh	1800-192047	19429	1800-192047	REF		
L4	B1-Q3	Inductor, var, 210 mh	1800-192047	19429	1800-192047	REF		
P5	D5-U1	Connector, male, 22 contact, chassis mount	2107-149351	95354	MDR-622B	REF		
Q1	I2-Q2	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	30	2	
Q2	J4-N5	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
Q3	J3-Q3	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
Q4	K2-N5	Transistor, Type 2N696	4805-148601	04713	Type 2N696	REF		
Q5	J5-Q2	Transistor, Type 2N696	4805-148601	04713	Type 2N696	REF		
Q6	K3-P2	Transistor, Type 2N696	4805-148601	04713	Type 2N696	REF		
Q7	K3-Q2	Transistor, Type 2N696	4805-148601	04713	Type 2N696	REF		
Q8	F2-S2	Transistor, Type 2N1177	4805-168302	49671	Type 2N1177	REF		
Q9	F5-S2	Transistor, Type 2N1177	4805-168302	49671	Type 2N1177	REF		
Q10	D4-Q2	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
Q11	D1-Q4	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
Q12	C5-Q2	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
Q13	E2-Q2	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
Q14	E4-Q5	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
Q15	E1-Q2	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
Q16	D4-R1	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q17	G1-P5	Transistor, Type 2N396A	2805-148585	49671	Type 2N396A	REF		
Q18	H2-Q1	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
Q19	G4-P5	Transistor, Type 2N396A	4805-148585	49671	Type 2N396A	REF		
R8	D5-R4	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R9	I3-Q4	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R10	I3-Q2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R11	I1-Q4	Res, comp, 560Ω ±5%, 1/4w	4704-147991	01121	CB5615	REF		
R12	J1-N4	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R13	I4-P3	Res, comp, 220k ±5%, 1/4w	4704-160937	01121	CB2245	6		
R14	I4-Q5	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R15	J3-Q2	Res, comp, 220k ±5%, 1/4w	4704-160937	01121	CB2245	REF		
R16	K4-Q2	Res, comp, 68Ω ±5%, 1/4w	4704-147918	01121	CB6805	REF		
R17	K3-P5	Res, comp, 68Ω ±5%, 1/4w	4704-147918	01121	CB6805	REF		
R18	K3-P4	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R19	K3-P3	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R20	K5-P3	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R21	J3-Q1	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R22	J5-Q3	Res, comp, 22k ±5%, 1/4w	4704-148130	01121	CB2235	REF		
R23	H4-Q5	Res, comp, 390Ω ±5%, 1/4w	4704-147975	01121	CB3915	2		
R24	C3-Q4	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R25	C3-Q3	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R26	C3-Q4	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R27	D3-Q1	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R28	D3-R4	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R29	D2-Q3	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R30	D2-Q1	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R31	C4-P1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R32	E2-R4	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R33	F1-R5	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R34	E2-S4	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R35	F2-R5	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R37	D5-P4	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R38	F5-Q2	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R39	H1-Q5	Res, comp, 390Ω ±5%, 1/4w	4704-147975	01121	CB3915	REF		
R40	E3-Q2	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R41	E4-R3	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R42	E3-R3	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R43	E5-R3	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R44	E4-Q3	Res, comp, 220k ±5%, 1/4w	4704-160937	01121	CB2245	REF		
R45	F1-P1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R46	E5-Q3	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R47	F3-R3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R48	G1-Q3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R49	F4-N5	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R50	G2-Q3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R51	G3-Q1	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R52	H4-P2	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R53	H3-N5	Res, comp, 15k ±5%, 1/4w	4704-148114	01121	CB1535	REF		
R54	H4-P4	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R55	H1-Q1	Res, comp, 220k ±5%, 1/4w	4704-160937	01121	CB2245	REF		
R56	H2-P1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R57	G5-Q1	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R58	G3-Q3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R59	E4-N4	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R60	E2-S1	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R61	E3-S5	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R62	G5-S1	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R63	F4-R5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R64	H1-S2	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R65	G2-S1	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R66	F4-S1	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R67	F3-S4	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R68	I4-P3	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R72	G3-T1	Res, comp, 22Ω ±5%, 1/4w	4704-147884	01121	CB2205	REF		
R73	H3-S5	Res, comp, 22Ω ±5%, 1/4w	4704-147884	01121	CB2205	REF		
R75	B2-T1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
TP1	F4-P1	Test point, black	2109-149112	74970	105-0753	REF		
TP2	F3-P1	Test point, green	2109-149120	74970	105-0754	REF		
TP3	F2-P1	Test point, green	2109-149120	74970	105-0754	REF		
TP4	C1-Q3	Test point, green	2109-149120	74970	105-0754	REF		
TP5	C4-R2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP6	D1-R2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP7	C5-R2	Test point, green	2109-149120	74970	105-0754	REF		
TP8	B3-P1	Test point, black	2109-149112	74970	105-0753	REF		
		Transipad, for TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A9		POWER SUPPLY MODULE Figure 5-10	1702-191510 (207-1-406)	19429	1702-191510	REF		
C1	J1-Q1	Cap, elect, 500 uf +150/-10%, 15v	1502-160101	88419	BR500-15	2		
C2	G3-R4	Cap, elect, 500 uf +150/-10%, 15v	1502-160101	88419	BR500-15	REF		
C3	J2-P3	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C4	H4-R3	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C5	J4-R2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C6	J3-Q4	Cap, elect, 3.3 uf ±20%, 25v	1502-183061	06001	76F02KC3R3	2		
C7	H5-Q1	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C8	I3-P4	Cap, elect, 3.3 uf ±20%, 25v	1502-183061	06001	76F02KC3R3	REF		
C9	E3-P5	Cap, elect, 500 uf +150/-10%, 50v (207-4, -5 only)	1502-160127	88419	BR500-50			
C10	G1-S1	Cap, mica, 2,200 pf ±5%, 500v	1504-148346	88419	CD19F222J	2		E
C10	G1-S1	Cap, cer, 0.05 uf +80/-20%, 500v	1501-105676	56289	33C53B	2		F
C11	K2-S1	Cap, mica, 2,200 pf ±5%, 500v	1504-148346	88419	CD19F222J	REF		E
C11	K2-S1	Cap, cer, 0.05 uf +80/-20%, 500v	1501-105676	56289	33C58B	REF		F
CR1	I2-R4	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR2	H5-R4	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR3	H1-S5	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR4	I4-T1	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR5	J3-S5	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR6	J4-Q5	Diode, zener, 10.0v, Type 1N758	4803-180406	07910	Type 1N758	2	1	
CR9	H5-Q3	Diode, zener, 10.0v, Type 1N758	4803-180406	07910	Type 1N758	REF		
CR10	F1-S2	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR11	F2-R5	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR12	F5-Q5	Diode, Type 1N4817 (207-4B, -5B only)	4802-116111	05277	Type 1N4817			
CR13	F5-Q2	Diode, Type 1N4817 (207-4B, -5B only)	4802-116111	05277	Type 1N4817			
CR14	E2-S3	Diode, Type 1N4817 (207-4B, -5B only)	4802-116111	05277	Type 1N4817			
CR15	D5-R4	Diode, Type 1N4817 (207-4B, -5B only)	4802-116111	05277	Type 1N4817			
CR17	D4-R2	Diode, Type 1N4817 (207-4B, -5B only)	4802-116111	05277	Type 1N4817			
CR18	D2-S5	Diode, zener, 5v, Type 1N3154 (207-4, -5 only)	4803-154815	04713	Type 1N3154			
CR19	H4-T3	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR20	I2-T2	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR21	I1-T1	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR22	I4-T1	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR23	F1-T2	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR24	E3-T1	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR25	F4-S5	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
CR26	E5-S5	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		

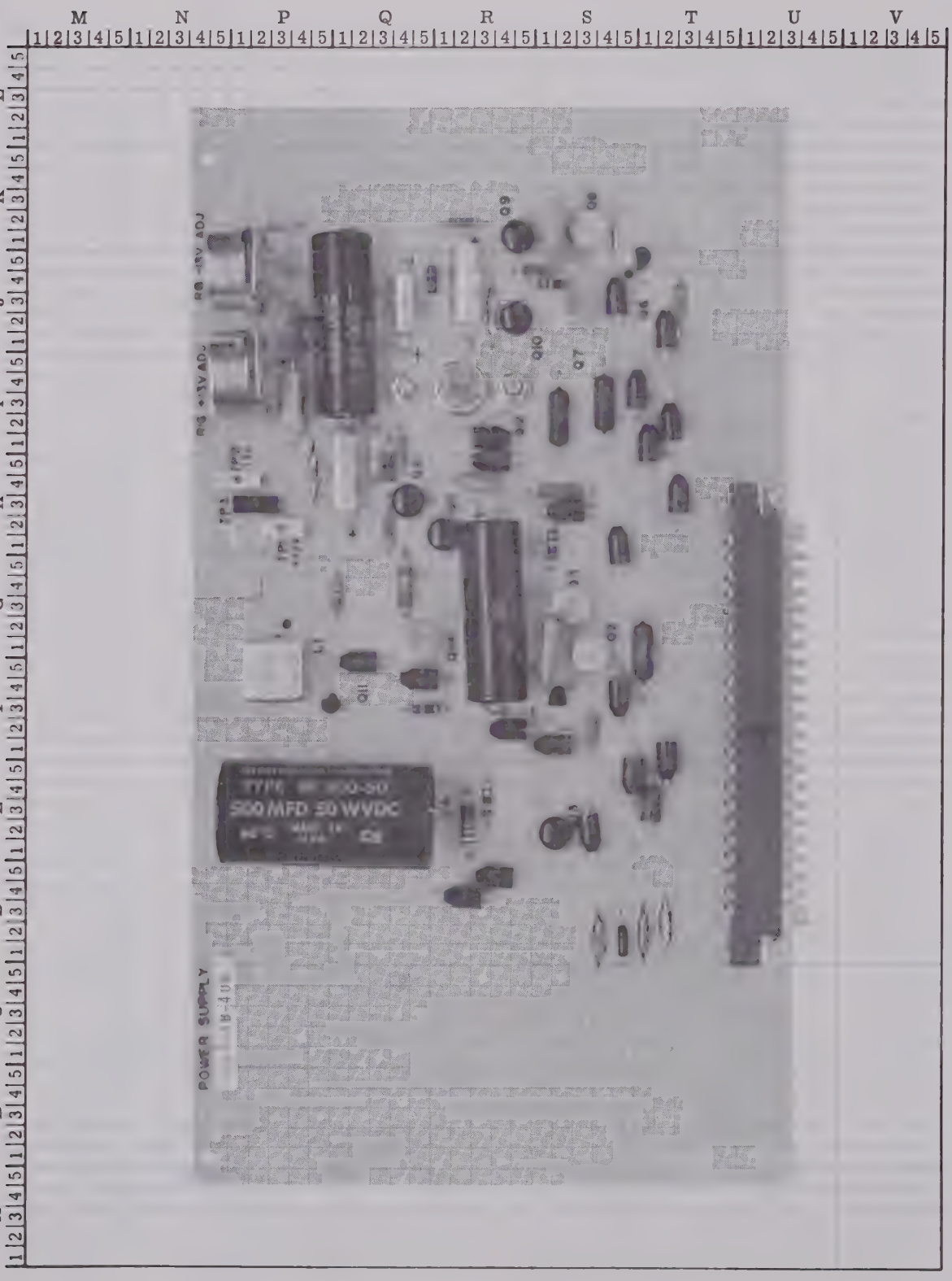


Figure 5-10. POWER SUPPLY MODULE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
CR27	H3-S2	Diode, Type 1N4817	4802-116111	05277	Type 1N4817	REF		
L1	F5-P3	Inductor (207-4, -5 only)	1800-163964	19429	1800-163964			
P6	F2-U1	Connector, male, 22 contact, chassis mount	2107-149351	95354	MDR-622B	REF		
Q1	F4-S2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q2	G1-S3	Transistor, Type 2N696	4805-148601	04713	Type 2N696	REF		
Q3	G3-S2	Transistor, Type 2N696	4805-148601	04713	Type 2N696	REF		
Q4	H3-Q4	Transistor, Type 2N3643	4805-182196	04713	Type 2N3643	REF		
Q5	H2-R1	Transistor, Type 2N3643	4805-182196	04713	Type 2N3643	REF		
Q6	J5-T1	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q7	J3-S3	Transistor, Type 2N696	4805-148601	04713	Type 2N696	REF		
Q8	K2-S3	Transistor, Type 2N696	4805-148601	04713	Type 2N696	REF		
Q9	K1-R5	Transistor, Type 2N3643	4805-182196	04713	Type 2N3643	REF		
Q10	J2-R5	Transistor, Type 2N3643	4805-182196	04713	Type 2N3643	REF		
Q11	F3-Q1	Transistor, Type 2N3638 (207-4B, -5B only)	4805-169375	04713	Type 2N3638			
Q12	I4-R2	Transistor, RCA Type 40250	4805-183004	95303	Type 40250	REF		
Q13	E2-S2	Transistor, Type 2N3643 (207-4B, -5B only)	4805-182196	04713	Type 2N3643			
Q14	G1-Q5	Transistor, Type 2N1306 (207-4B, -5B only)	4805-148825	01295	Type 2N1306			
R1	H4-S2	Res, comp, 1k ±5%, 1/2w	4704-108597	01121	EB1025	1		
R2	I3-S2	Res, comp, 5.6Ω ±5%, 2w	4704-183111	01121	HB56G5	1		
R3	I3-S4	Res, comp, 0.82Ω ±5%, 2w	4704-183129	01121	HB82S5	2		
R4	J3-T3	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R5	J4-S1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R6	K2-R2	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R7	J5-S1	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R8	J5-N5	Res, var, ww, 1k ±20%, 1-1/4w	4702-113266	71450	Type 110	2		
R9	K2-P3	Res, met flm, 249Ω ±1%, 1/8w	4705-168203	12400	Type CEA T-O	REF		
R10	J2-R3	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R11	G1-T1	Res, comp, 0.82Ω ±5%, 2w	4704-183129	01121	HB82S5	REF		
R12	I1-Q4	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R14	I1-Q3	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R15	H5-P5	Res, met flm, 249Ω ±1%, 1/8w	4705-168203	12400	Type CEA T-O	REF		
R16	I4-P1	Res, var, ww, 1k ±20%, 1-1/4w	4702-113266	71450	Type 110	REF		
R18	F3-Q5	Res, comp, 68Ω ±5%, 1/4w (207-4B, -5B only)	4704-147918	01121	CB6805			
R19	G4-Q1	Res, comp, 15k ±5%, 1/4w (207-4B, -5B only)	4704-148114	01121	CB1535			
R20	E4-R3	Res, comp, 27Ω ±5%, 1/4w (207-4B, -5B only)	4704-160812	01121	CB2705			
R21	E2-R2	Res, comp, 3.9Ω ±5%, 1/2w (207-4B, -5B only)	4704-188490	01121	EB39G5			
R22	G4-Q4	Res, comp, 220Ω ±5%, 1/2w (207-4B, -5B only)	4704-186031	01121	EB2215			
R24	D2-S4	Res, met flm, 10k ±1%, 1/8w (207-4, -5 only)	4705-168260	12400	Type CEA T-O			

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R25	D2-T1	Res, met flm, 46.4k ±1%, 1/8w (207-4, -5 only)	4705-188375	12400	Type CEA T-O			
R26	F2-S4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R27	H1-S1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R28	H2-Q3	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R29	D2-T2	Res, met flm, 1k ±1%, 1/8w (207-4, -5 only)	4705-168229	12400	Type CEA T-O			
TP1	H2-P3	Test point, yellow	2109-149138	74970	105-0757	REF		
TP2	H4-P1	Test point, yellow	2109-149138	74970	105-0757	REF		
TP3	H3-P2	Test point, black	2109-149112	74970	105-0753	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		
A10		**FREQUENCY SYNTHESIZER ASSEMBLY - Figure 5-11**	3158-191742 (207-1-431)	19429	3158-191742	REF		
A27	D5-R5	Voltage-Controlled Oscillator Assembly (See Figure 5-12)	1702-191536 (207-1-408)	19429	1702-191536	1		
A28	F4-Q1	Track Rate Switch Assembly (See Figure 5-13)	5110-191767 (207-1-434)	19429	5110-191767	1		
A29	F1-N4	Preset Counter A Assembly (See Figure 5-13)	1702-191544 (207-1-409)	19429	1702-191544	1		
A30	E5-P1	Preset Counter B Assembly (See Figure 5-14)	1702-191551 (207-1-410)	19429	1702-191551	1		
A31	E3-P4	Preset Counter C Assembly (See Figure 5-14)	1702-191569 (207-1-411)	19429	1702-191569	1		
A32	E2-Q1	Preset Counter D Assembly (See Figure 5-15)	1702-191577 (207-1-412)	19429	1702-191577	1		
A33	D5-Q3	Preset Counter E Assembly (See Figure 5-15)	1702-191585 (207-1-413)	19429	1702-191585	1		
A34	E2-Q5	Preset Counter F Assembly (See Figure 5-16a) (For Serial Numbers 112 to 224)	1702-191593 (207-1-414)	19429	1702-191593	1		
A34	E2-Q5	Preset Counter F Assembly (See Figure 5-16b) (For Serial Number 225 and on)	1702-215889 (207-1-424)	19429	1702-215889	1		

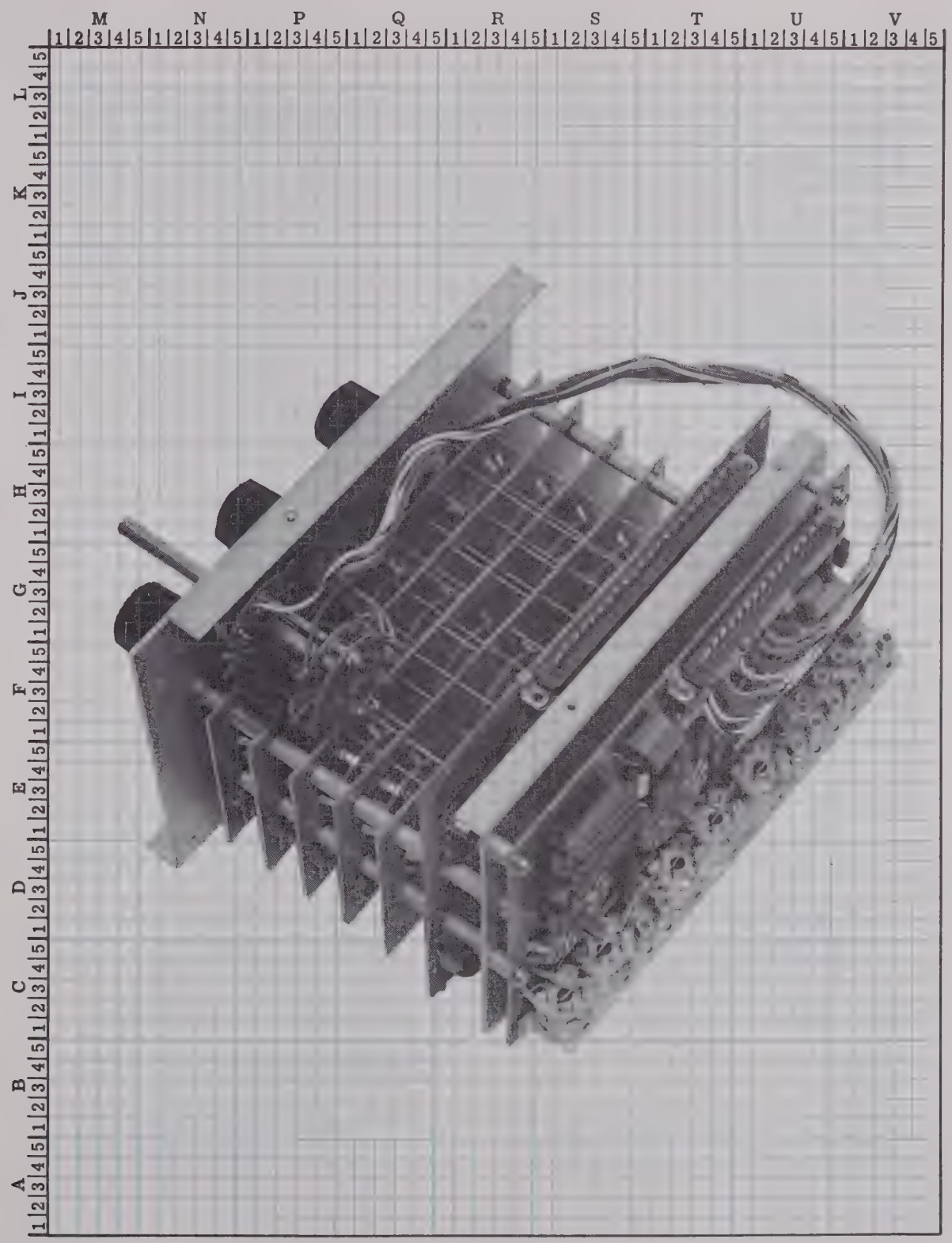


Figure 5-11. FREQUENCY SYNTHESIZER ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A27		VOLTAGE CONTROLLED OSCILLATOR - Figure 5-12	1702-191536 (207-1-208)	19429	1702-191536	REF		
A38	I1-U2	Varactor, Diode Assembly	4802-191783	19429	4802-191783	1	1	
C1	D1-S3	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	REF		
C2	D5-T3	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C3	F4-T5	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C4	G5-T4	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C5	H3-T4	Cap, mica, 330 pf ±5%, 500v	1504-148320	88419	CD19F332J	REF		
C6	I2-T2	Cap, elect, 1 uf +75/-10%, 25v	1502-165886	56289	30D105G025-AA4	REF		
C7	D4-N5	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	14		
C8	J3-S2	Cap, cer, 220 pf ±1%	1501-183301	00656	N220 S1-3	1	1	
C9	K4-S5	Cap, mica, 480 pf ±1%, 500v	1504-182931	88419	CD19F481F	1	1	
C10	I1-P1	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		
C11	J2-T2	Cap, cer, 200 pf ±1%	1501-183285	00656	N330 S1-3	2	1	
C12	K5-T3	Cap, mica, 691 pf ±1%, 500v	1504-182915	19429	1504-182915	1		
C13	I4-N5	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		
C14	J4-U2	Cap, cer, 240 pf ±1%	1501-183293	00650	NPO S1-3	1	1	
C15	K5-U3	Cap, mica, 843 pf ±1%, 500v	1504-182907	19429	1504-182907	1		
C16	I3-P1	Cap, var, cer, 2 -10 pf, 500v	1509-182188	71590	829	REF		
C17	J3-T5	Cap, cer, 200 pf ±1%	1501-183319	00656	N470 S1-3	1	1	
C18	K3-T4	Cap, mica, 1,075 pf ±1%, 500v	1504-182899	19429	1504-182899	1	1	
C19	E1-N5	Cap, var, cer, 2 -10 pf, 500v	1509-182188	71590	829	REF		
C20	J3-S5	Cap, cer, 200 pf ±1%	1501-183285	00656	NPO S1-3	REF		
C21	K5-S3	Cap, mica, 593 pf ±1%, 500v	1504-182923	19429	1504-182923	1	1	
C22	G1-S3	Cap, cer, 47 pf ±2.5%	1501-183434	00656	NPO S1-2	1	1	
C23	F4-R2	Cap, cer, 39 pf ±2.5%	1501-183426	00656	NPO S1-2	1	1	
C24	F5-S3	Cap, cer, 36 pf ±2.5%	1501-188722	00656	NPO S1-2	3	1	
C25	G3-S3	Cap, cer, 36 pf ±2.5%	1501-188722	00656	NPO S1-2	REF		
C26	H1-S3	Cap, cer, 36 pf ±2.5%	1501-188722	00656	NPO S1-2	REF		
C27	H3-S3	Cap, cer, 33 pf ±2.5%	1501-183418	00656	NPO S1-2	1	1	
C28	H5-S3	Cap, cer, 30 pf ±2.5%	1501-183400	00656	NPO S1-2	2	1	
C29	I3-S1	Cap, cer, 30 pf ±2.5%	1501-183400	00656	NPO S1-2	REF		
C30	I3-Q3	Cap, cer, 27 pf ±2.5%	1501-183392	00656	NPO S1-2	1	1	
C31	C5-Q4	Cap, cer, 10 pf ±5%, 500v	1501-106633	71590	Type CC20	1		
C32	C5-R2	Cap, cer, 3.3 pf ±0.25%	1501-183335	00656	NPO S1-1	2	1	
C33	D1-R4	Cap, cer, 3.9 pf ±0.25%	1501-183327	00656	NPO S1-1	4	1	
C34	D3-S1	Cap, cer, 3.9 pf ±0.25%	1501-183327	00656	NPO S1-1	REF		
C35	E4-S1	Cap, cer, 3.9 pf ±0.25%	1501-183327	00656	NPO S1-1	REF		
C36	F2-R5	Cap, cer, 3.6 pf ±0.25%	1501-188714	00656	NPO S1-1	2	1	
C37	E1-S2	Cap, cer, 3.6 pf ±0.25%	1501-188714	00656	NPO S1-1	REF		
C38	C5-R1	Cap, cer, 3.9 pf ±0.25%	1501-183827	00656	NPO S1-1	REF		
C39	C5-Q2	Cap, cer, 3.3 pf ±0.25%	1501-183335	00656	NPO S1-1	REF		
C40	B4-P1	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		
C41	D5-T5	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		

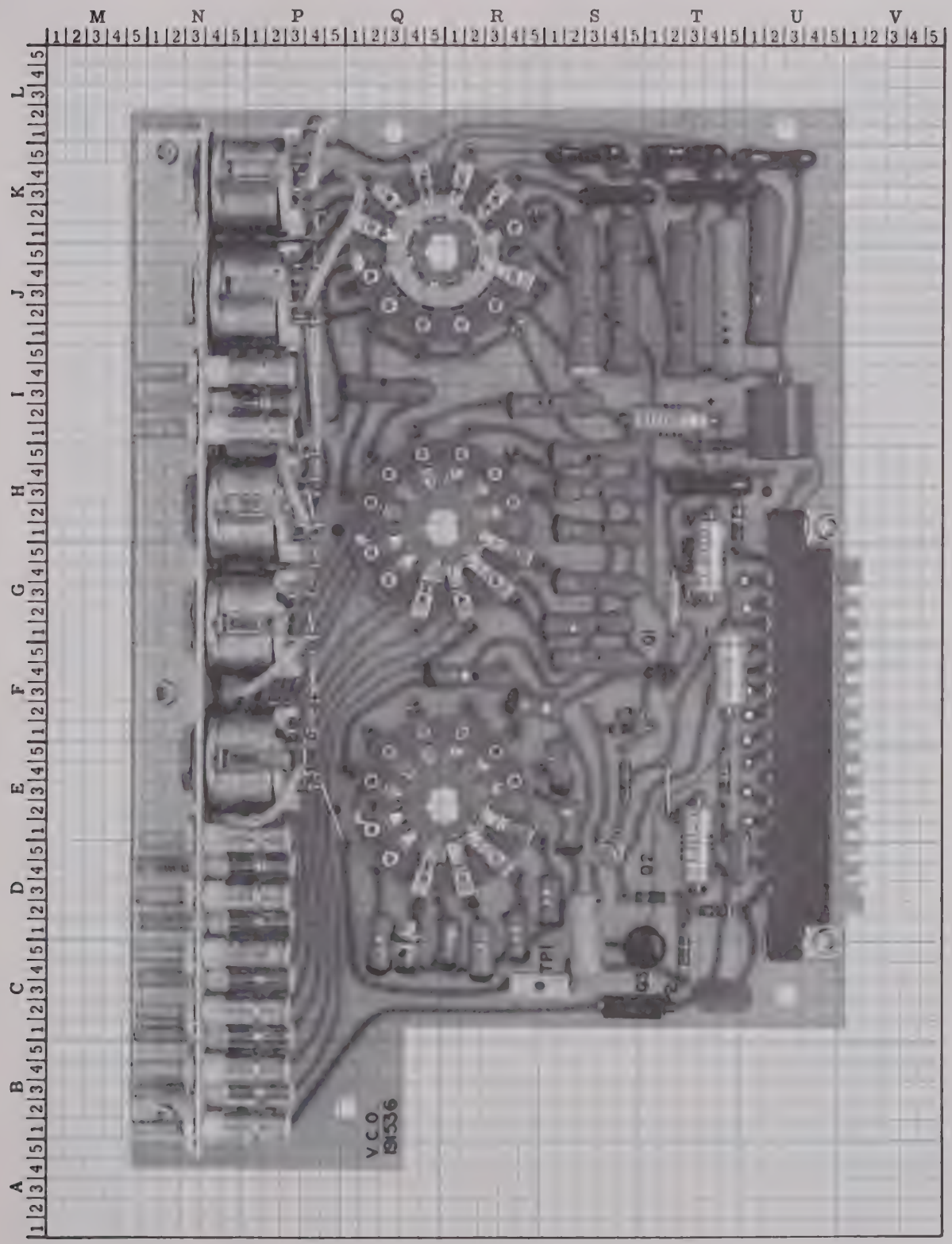


Figure 5-12. VOLTAGE-CONTROLLED OSCILLATOR ASSEMBLY

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
C42	C3-T4	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		
C43	C1-N5	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		
C44	C2-N5	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		
C45	C3-N5	Cap, var, cer, 5 - 10 pf, 500v	1509-182188	71590	829	REF		
C46	C5-N5	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		
C47	D1-N5	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		
C48	D3-N5	Cap, var, cer, 2 - 10 pf, 500v	1509-182188	71590	829	REF		
C49	C3-T4	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C50	D4-T5	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
CR1	F2-S5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	G5-T3	Diode, zener, 4.3v, Type 1N749A	4803-180455	07910	Type 1N749A	REF		
P7	E5-U3	Connector, male, 15 contact, chassis mount	2107-183194	95354	MDR-615B	3	1	
Q1	F4-T2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q2	D5-S4	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q3	C5-T1	Transistor, Type 2N3643	4805-182196	04713	Type 2N3643	REF		
R2	D3-T1	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R3	D2-T4	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R4	C5-T3	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R6	E4-T5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R7	F1-S5	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R8	E3-S5	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R9	H5-T4	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R10	G2-T2	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R11	H1-T5	Res, comp, 100k ±5%, 1/4w	4704-148189	01121	CB1045	REF		
S1F	E2-Q5	Switch, rotary	5107-181909	76854	253044FD	2		
S2G	H1-Q5	Switch, rotary	5107-181909	76854	253044FD	REF		
S3F	J5-Q5	Switch, rotary	5107-181891	76854	253043FD	1		
T1	E5-N5	Transformer, var, 99 uh	1800-192005	19429	1800-192005	1	1	
T2	H2-N5	Transformer, var, 54.8 uh	1800-192013	19429	1800-192013	1	1	
T3	K4-N5	Transformer, var, 33.5 uh	1800-192921	19429	1800-192921	1	1	
T4	J3-N5	Transformer, var	1800-192039	19429	1800-192039	2	1	
T5	G2-N5	Transformer, var	1800-192039	19429	1800-192039	REF		
TP1	C3-R5	Test point, yellow	2109-149138	74970	105-0757	REF		
TP2	C2-S5	Test point, black	2109-149112	74970	105-0753	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A28		**TRACK RATE SWITCH ASSEMBLY** Figure 5-13	5110-191767 (207-1-434)	19429	5110-191767	REF		
C1	H4-Q4	Cap, Ta, 6.8 uf ±10%, 35v	1508-182782	05397	K6R8C35K	2		
C2	H3-Q2	Cap, Ta, 22 uf ±10%, 15v	1508-182816	05397	K22C15K	3		
C3	H3-P4	Cap, Ta, 68 uf ±10%, 15v	1508-182824	05397	K68C15K	2		
C4	H2-P2	Cap, Ta, 220 uf ±10%, 10v	1508-182840	05397	K220C10K	4		
C5	H3-T5	Cap, Ta, 6.8 uf ±10%, 35v	1508-182782	05397	K6R8C35K	REF		
C6	H3-T3	Cap, Ta, 22 uf ±10%, 15v	1508-182816	05397	K22C15K	REF		
C7	H3-S5	Cap, Ta, 69 uf ±10%, 15v	1508-182824	05397	K68C15K	REF		
C8	H3-S3	Cap, Ta, 220 uf ±10%, 10v	1508-182840	05397	K220C10K	REF		
S9	T1-J1	Switch, rotary, 3p, 4 pos, 3 sect	5100-181750	19429	5100-181750	1		
A29		**PRESET COUNTER A** Figure 5-13	1702-191544 (207-1-409)	19429	1702-191544	REF		
CR1	D4-Q3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	E4-P3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR3	D4-S4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR4	E4-R4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR5	E1-U4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR6	E1-U5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR7	E3-U5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR8	E3-V1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
K9	E2-P3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K13	E2-R4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K17	E2-U1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
S1A	C5-P3	Switch section, rotary	5107-181826	76854	253037FD	4		
S2A	D1-R4	Switch section, rotary	5107-181826	76854	253037FD	REF		
S3A	D1-U1	Switch section, rotary	5107-181826	76854	253037FD	REF		

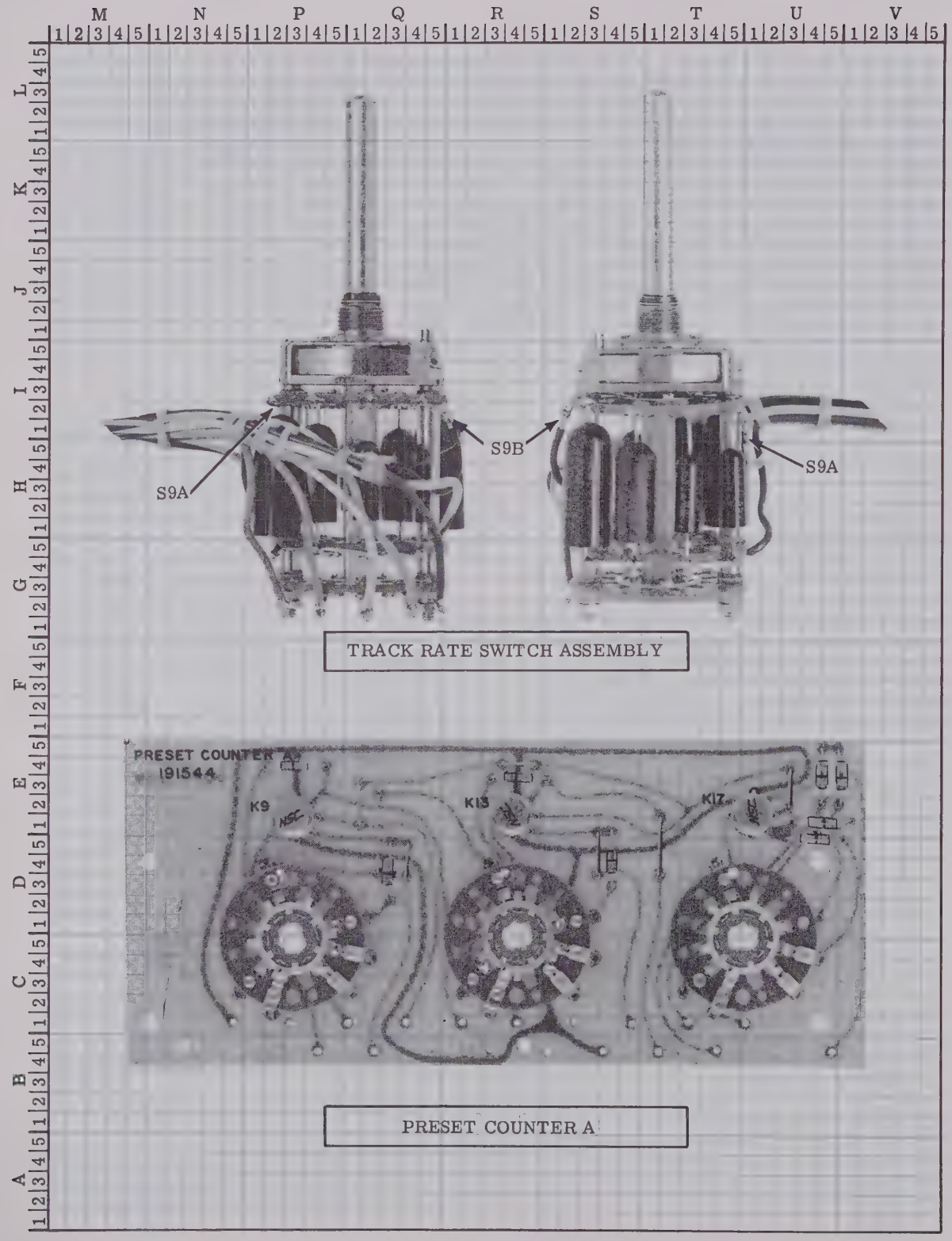


Figure 5-13. TRACK RATE SWITCH ASSEMBLY AND PRESET COUNTER A

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A30		**PRESET COUNTER B** Figure 5-14	1702-191551 (207-1-410)	19429	1702-191551	REF		
CR1	E1-P1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	E2-P5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR3	E2-S2	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR4	E1-S4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR5	E4-U5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR6	E4-V1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR7	E3-T5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR8	D5-T5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
K10	E2-P3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K14	E2-R4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K18	E2-U1	IC, RTL Flip Flop	5107-183053	19429	4800-183053	REF		
S1B	D1-P3	Switch section, rotary	5107-181842	19429	5107-181842	2		
S2B	D1-R5	Switch section, rotary	5107-181842	19429	5107-181842	REF		
S3B	D1-U1	Switch section, rotary	5107-181826	76854	253036FD	REF		
A31		**PRESET COUNTER C** Figure 5-14	1702-191569 (207-1-411)	19429	1702-191569	REF		
CR1	J4-Q2	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	J4-P1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR3	J2-S3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR4	J2-R1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR5	J5-U5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR6	J5-V1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR7	J2-T4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR8	J3-U4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
K11	J4-P3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K15	J4-R4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K19	J4-U1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
S1C	I3-P3	Switch section, rotary	5107-181859	76854	253039FD	2		
S2C	I3-R4	Switch section, rotary	5107-181859	76854	253039FD	REF		
S3C	I3-U1	Switch section, rotary	5107-181818	76854	253035FD	2		
TP1	J4-Q3	Test point, yellow	2109-149138	74970	105-0757	REF		
TP2	J5-S4	Test point, yellow	2109-149138	74970	105-0757	REF		

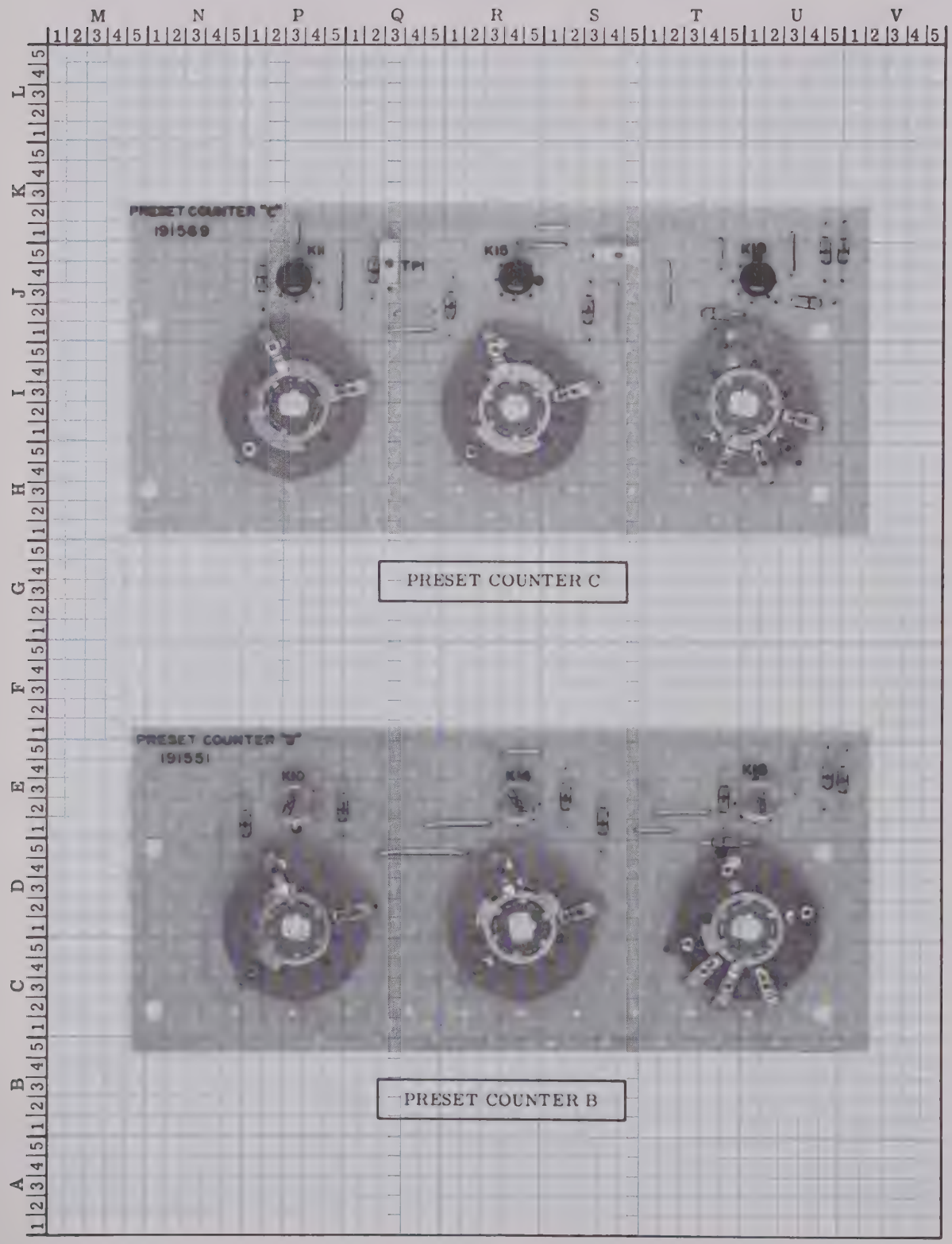


Figure 5-14. PRESET COUNTERS B AND C

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A32		**PRESET COUNTER D** **Figure 5-15**	1702-191577 (207-1-412)	19429	1702-191577	REF		
CR1	J2-Q3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	J2-P5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR3	J4-T1	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR4	J4-S3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR5	J5-U4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR6	J4-U4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR7	J3-U4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR8	J3-U5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
K12	J4-P3	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K16	J4-R4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K20	J4-U1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
S1D	I2-P3	Switch section, rotary	5107-181867	76854	253040FD	2		
S2D	I2-R4	Switch section, rotary	5107-181867	76854	253040FD	REF		
S3D	I2-T5	Switch section, rotary	5107-181818	76854	253035FD	REF		
A33		**PRESET COUNTER E** **Figure 5-15**	1702-191585 (207-1-413)	19429	1702-191585	REF		
C1	F1-R1	Cap, mylar, 0.022 uf ±10%, 100v	1507-182147	37942	PVC1122	3		
CR1	E1-S4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	D3-S5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
K23	E5-Q1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K24	E4-T1	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
Q1	E5-R4	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
R1	E4-R2	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R2	F1-S1	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
S1E	D2-P3	Switch section, rotary	5107-181875	76854	253041FD	1		
S2E	D2-R4	Switch section, rotary	5107-181792	76854	253033FD	1		
S3E	D2-T5	Switch section, rotary	5107-181800	76854	253034FD	1		

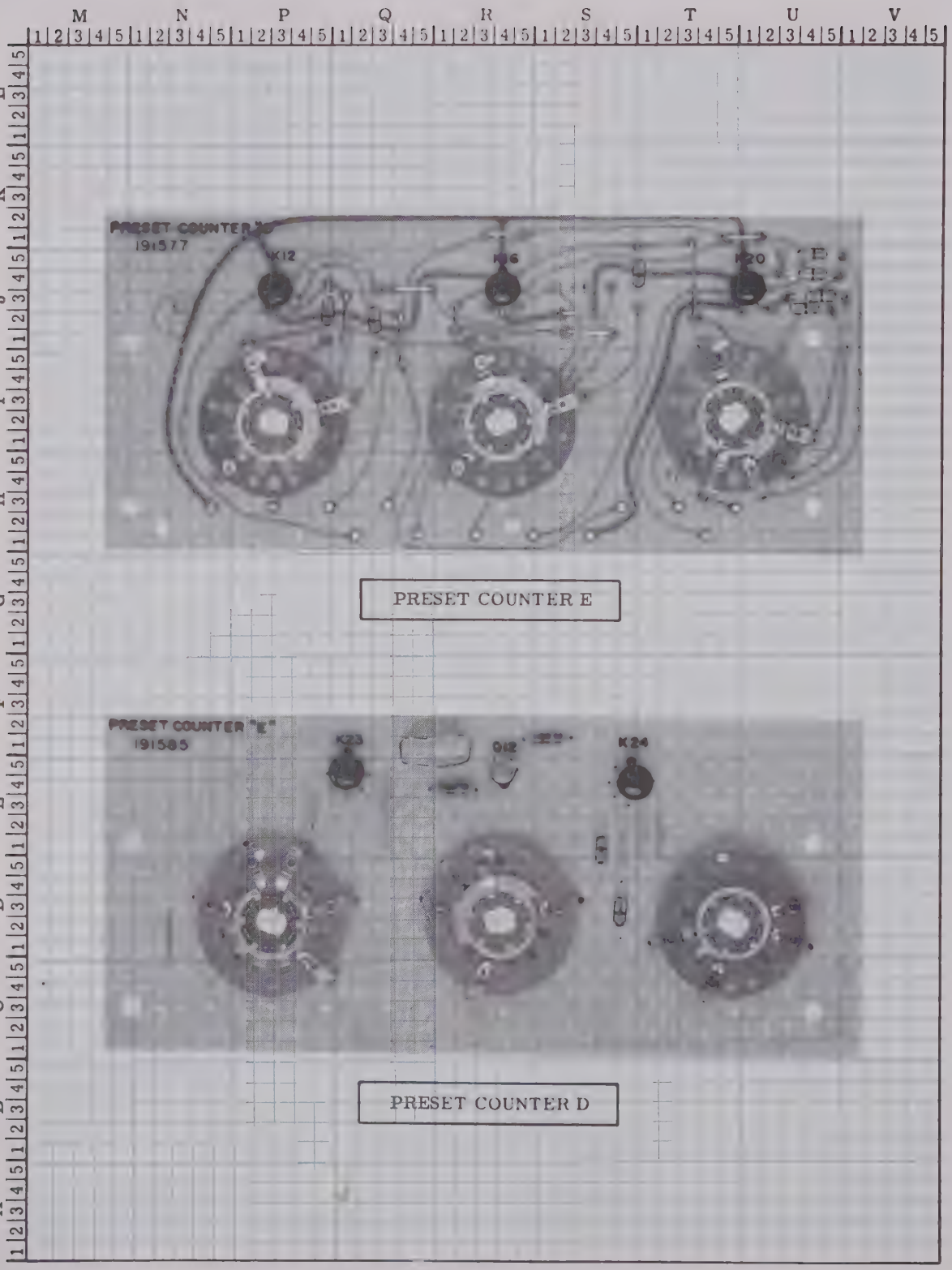


Figure 5-15. PRESET COUNTERS D AND E

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A34		**PRESET COUNTER F - Figure 5-16a**	1702-191593 (207-1-414)	19429	1702-191593	REF		
		This assembly was originally included in those instruments having serial numbers from 112 to 225. Some of the instruments were later returned to the factory for modification and this assembly was replaced by part number 1702-191593.						
C1	L1-S4	Cap, mica, 470 pf ±5%, 500v	1504-148429	88419	CD19F471J	REF		
C2	L2-P4	Cap, mica, 1,000 pf ±5%, 500v	1504-148387	88419	CD19F102J	REF		
C3	J4-M5	Cap, mylar, 0.022 uf ±10%, 100v	1507-182147	37942	PVC1122	REF		
C4	A4-P3	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C5	C1-R3	Cap, Ta, 3.3 uf ±10%, 15v	1508-182808	05397	K3R3C15K	REF		
C6	D1-R5	Cap, Ta, 220 uf ±10%, 10v	1508-182840	05397	K220C10K	REF		
C7	E1-T1	Cap, Ta, 0.68 uf ±10%, 35v	1508-182790	05397	KR68C35K	REF		
C8	E1-T3	Cap, mylar, 0.068 uf ±10%, 100v	1507-182170	37942	PVC1168	2		
C9	H3-T5	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G025-DB4	REF		
C10	D2-T4	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C11	D1-T5	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C12	I3-Q5	Cap, mica, 100 pf ±5%, 500v	1504-148494	88419	CD15F101J	1		
C13	E5-Q5	Cap, mica, 330 pf ±5%, 500v	1504-148445	88419	CD15F331J	REF		
C14	D4-R3	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	83445	C426ARE125	REF		
CR1	F5-Q5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	G1-P5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR3	E4-Q4	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR4	F2-P5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR5	B2-P3	Diode, zener, 6.2v Type 1N753	4803-180497	07910	Type 1N753	REF		
CR6	E4-N2	Diode, zener, 6.3v Type 1N3497	4803-168757	03877	Type 1N3497	2	1	
CR7	F1-P3	Diode, Type 1N4148	2802-203323	89732	Type 1N4148	REF		
CR8	B4-P5	Diode, Type 1N4148	4802-203323	89732	Type 1N4148	REF		
K1	K3-P4	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K2	E5-R3	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K3	H3-P2	IC, RTL Flip Flop	4800-183053	19420	4800-183053	REF		
K4	G4-N4	IC, RTL Flip Flop	4800-183053	19420	4800-183053	REF		
K5	I2-P4	IC, RTL Flip Flop	4800-183053	19420	4800-183053	REF		
K6	J2-P4	IC, RTL Flip Flop	4800-183053	19420	4800-183053	REF		
K7	G3-P4	IC, RTL Flip Flop	4800-183053	19420	4800-183053	REF		
K8	K1-N3	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K21	K5-N3	IC, RTL Buffer	4800-183020	12040	SP-5037	2	1	
K22	J1-N5	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
P8	F3-U4	Connector, male, 22 contact, chassis mount	2107-149351	95354	MDR-622B	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q1	E1-P1	Transistor, Type 2N706A	4805-148593	01205	Type 2N706A	REF		
Q2	D3-N2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q3	E2-N2	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q4	F2-N3	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q5	F1-P1	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q6	G1-N1	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q7	B5-P2	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q8	B1-Q1	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q9	H1-T1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q10	G2-S5	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q11	K4-T2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q12	F3-Q3	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
R1	K2-S5	Res, comp, 10K ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R2	L1-N1	Res, comp, 1K ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R3	I1-N2	Res, var, ww, 3k ±20%, 1/2w	4702-153429	71450	Type 115	3		
R4	J2-N2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R5	E1-P3	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R6	E3-P1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R7	D5-N2	Res, var, ww, 1k ±1%, 1/2w	4702-184408	19429	4702-184408	1		
R8	D3-M5	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R9	E2-P5	Res, met flm, 100Ω ±5%, 1/8w	4705-168195	12400	Type CEA T-O	REF		
R10	E4-P4	Res, met flm, 1k ±1%, 1/8w	4705-168229	12400	Type CEA T-O	REF		
R11	F4-N3	Res, var, ww, 20k ±1%, 1/2w	4707-184424	19429	4707-184424	1		
R12	E5-N2	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R13	D2-N5	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R14	C2-P1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R15	C3-P3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R16	C2-P3	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R17	C1-Q3	Res, met flm, 1k ±1%, 1/8w	4705-168229	12400	Type CEA T-O	REF		
R18	C2-N2	Res, var, ww, 500Ω ±20%, 2w	4702-183954	71450	Type 115	1		
R19	B4-N4	Res, met flm, 1k ±1%, 1/8w	4705-168229	12400	Type CEA T-O	REF		
R20	C4-R2	Res, var, ww, 6.45k ±1%, 1/2w	4707-184416	19429	4707-184416	2		
R21	D1-T2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R22	C5-R3	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R23	C3-R2	Res, var, ww, 6.45k ±1%, 1/2w	4707-184416	19429	4707-184416	REF		
R24	D1-Q5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R25	E1-S4	Res, comp, 2.7k ±5%, 1/4w	4704-170720	01121	CB2725	3		
R26	E5-T2	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R27	F3-T1	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R28	G1-S4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R29	G4-S2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R30	G5-S4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R31	G1-S2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R32	G2-T4	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R33	L1-R2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R34	J4-P2	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R35	E5-Q4	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R36	F1-Q2	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R37	G3-P2	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
S2F	H1-Q5	Switch section, rotary	5107-181784	76854	253032FD	1		

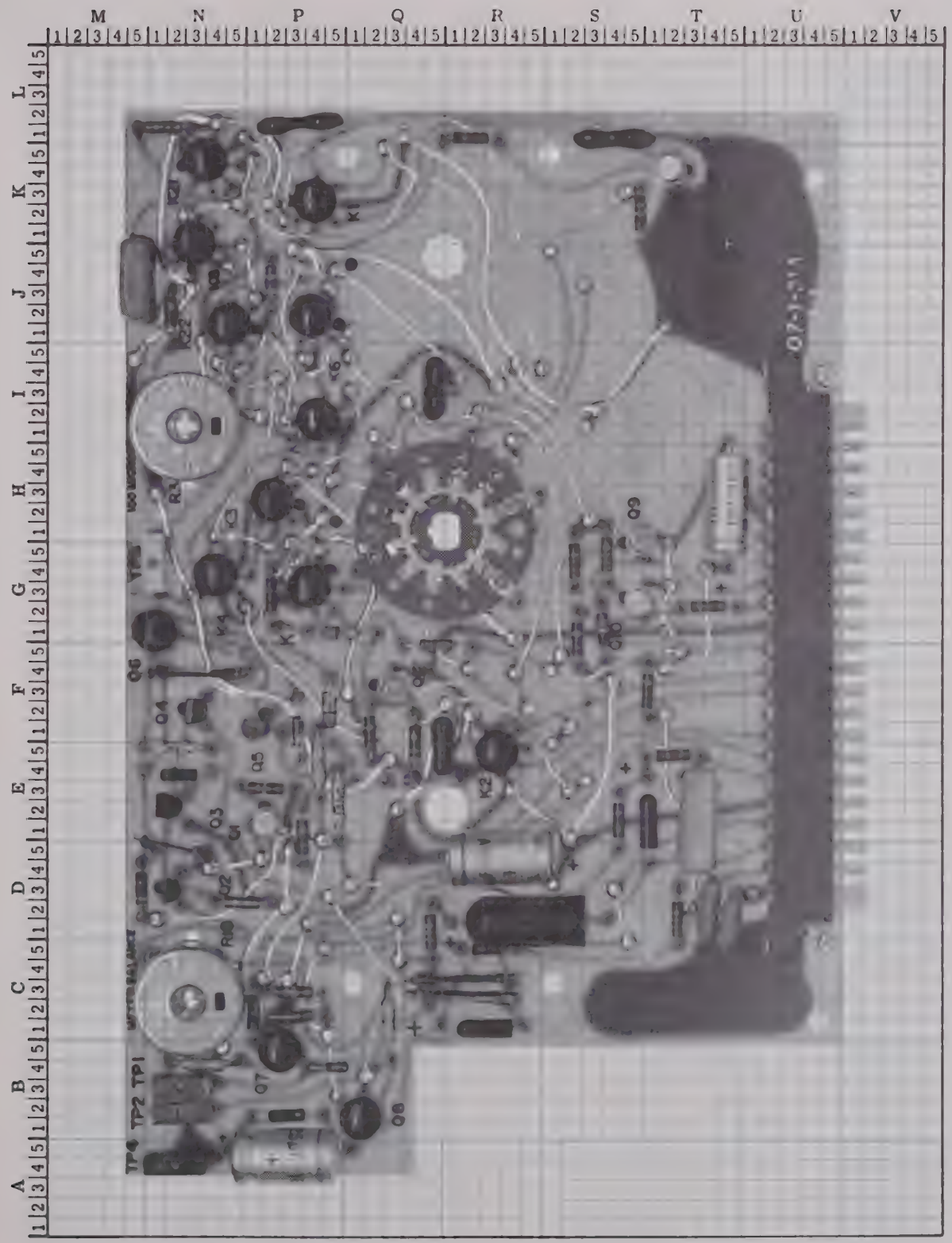


Figure 5-16a. PRESET COUNTER F (S/N 112 to 224)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
TP1	B3-N2	Test point, green	2109-149120	74970	105-0754	REF		
TP2	B2-N2	Test point, green	2109-149120	74970	105-0754	REF		
TP3	G5-N1	Test point, yellow	2109-149138	74970	105-0757	REF		
TP4	A4-N2	Test point, black	2109-149112	74970	105-0753	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		
A34		**PRESET COUNTER F Figure 5-16b**	1702-215889 (207-1-424)	19429	1702-215889	REF		
C1	K1-P3	Cap, mica, 680 pf ±5%, 500v	1504-148403	88419	CD19F68IJ	1		
C2	I5-P3	Cap, mica, 1,000 pf ±5%, 500v	1504-148387	88419	CD19F102J	REF		
C3	I4-P4	Cap, mica, 47 pf ±5%, 500v	1504-148536	88419	CD15E470J	REF		
C4	I1-Q1	Cap, poly, 0.047 uf ±2%, 100v	1507-170449	02799	IPJ473G	REF		
C5	E3-T4	Cap, mica, 330 pf ±5%, 500v	1504-148445	88410	CD15F33IJ	REF		
C6	D1-Q1	Cap, Ta, 2.2 uf ±20%, 15v	1508-161927	56289	196D225X 0020	1	1	
C7	F2-S3	Cap, mica, 220 pf ±5%, 500v	1504-170423	88419	CD15F221J	1		
C8	C3-Q4	Cap, Ta, 22 uf ±10%, 15v	1508-182816	05397	TDB326	REF		
C9	F1-R1	Cap, mylar, 0.022 uf ±10%, 100v	1507-182147	37942	PVC1122	REF		
C10	C4-R1	Cap, Ta, 220 uf ±10%, 10v	1508-182840	05397	TDD564	REF		
C11	C4-R4	Cap, mylar, 0.22 uf ±10%, 80v	1507-159392	56289	2249R8	1		
C12	D5-T4	Cap, mylar, 0.068 uf ±10%, 100v	1507-182170	37942	PVC1168	REF		
C13	D5-N4	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C14	F3-P4	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C15	C3-T5	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C16	D1-T4	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C17	J4-R4	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C18	D1-U1	Cap, cer, 0.05 uf ±20%, 50v	1501-149161	56289	55C23A1	REF		
C19	C3-S4	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C20	K2-U3	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
C21	H4-T4	Cap, elect, 125 uf +50/-10%, 16v	1502-186296	73445	C426ARE125	REF		
CR1	H5-N5	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR2	G3-N3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR3	H1-P3	Diode, Type 1N270	4802-149187	94145	Type 1N270	REF		
CR4	D2-P5	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR5	D2-P1	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR6	C5-N2	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR7	C5-N3	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR8	F2-N4	Diode, Type 1N4148	4802-203323	89730	Type 1N4148	REF		
CR9	E2-N3	Diode, zener, 6.3v, Type 1N3497	4803-168757	03877	Type 1N3497	REF		
CR10	D5-N3	Diode, zener, 6.2v, Type 1N753	4803-180497	07910	Type 1N753	REF		
CR11	C1-T4	Diode, zener, 6.2v, Type 1N753	4803-180497	07910	Type 1N753	REF		
K1	F3-T1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K2	H1-S5	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K3	I1-T1	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K4	J5-S5	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		

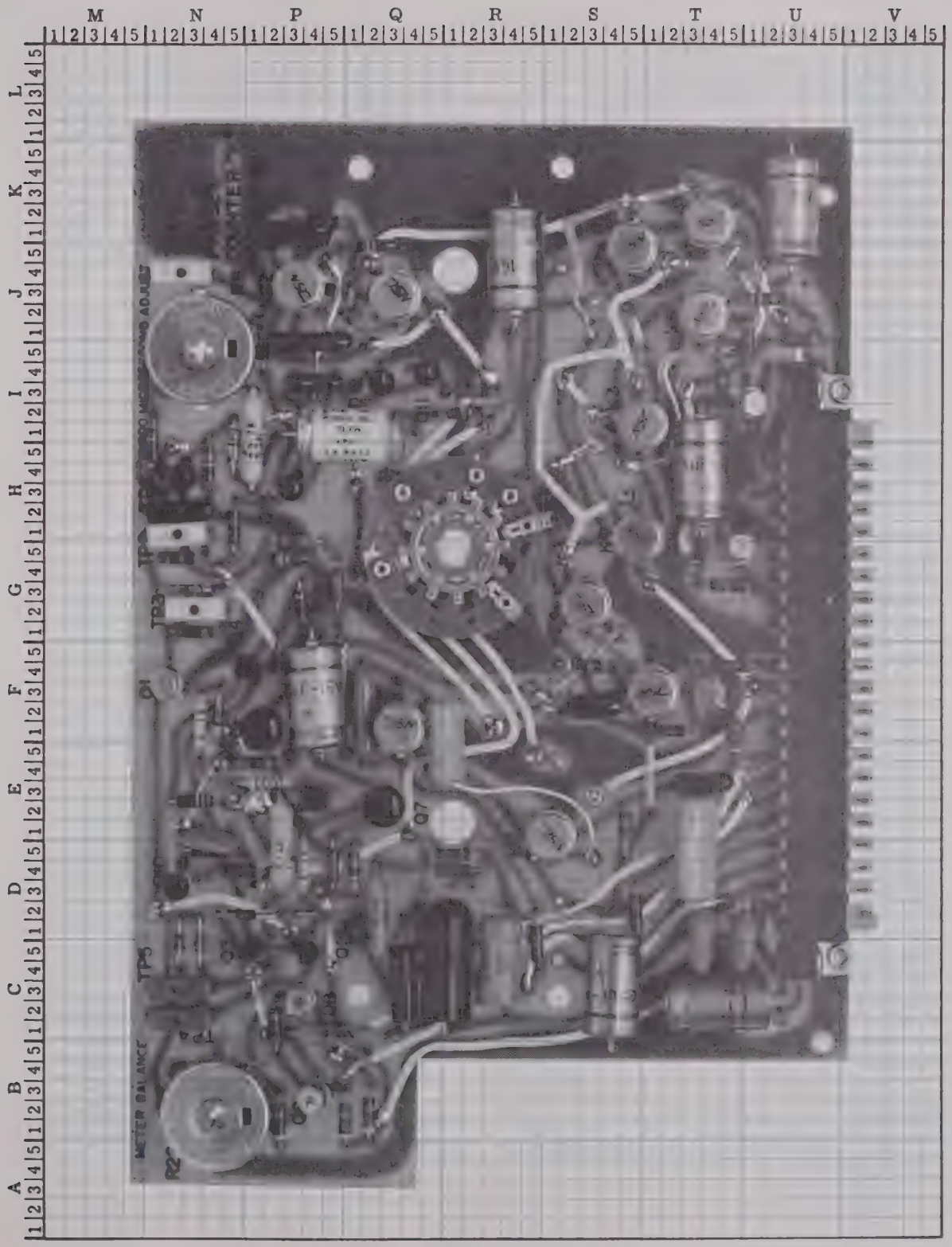


Figure 5-16b. PRESET COUNTER F (S/N 225 and on)

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
K5	K1-T4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K6	J2-T4	IC, RTL Flip Flop	4800-183053	19429	4800-183053	REF		
K7	E1-S1	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K8	F1-Q3	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K21	J3-Q3	IC, RTL Buffer	4800-183020	12040	SP-5035	REF		
K22	J3-P3	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
K24	G2-S3	IC, RTL Dual 2-Input Gate	4800-183038	12040	SP-5035	REF		
P8	F3-U4	Connector, male, 22 contact, chassis mount	2107-149351	95354	MDR-622B	REF		
Q1	F3-N2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q2	C5-P4	Transistor, Type 2N4126	4805-215897	04713	Type 2N4126	1	1	
Q3	C5-P1	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q4	F4-P1	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q5	F1-P1	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q6	E3-P4	Transistor, Type 2N3638	4805-169375	04713	Type 2N3638	REF		
Q7	E2-Q2	Transistor, Type 2N3643	4805-182196	01295	Type 2N3643	REF		
Q8	C2-P3	Transistor, Siliconix, Type FN-323	4805-102864	17856	Type FN-323	2	1	
Q9	B3-P4	Transistor, Siliconix, Type FN-323	4805-192864	17856	Type FN-323	REF		
Q10	D3-N2	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		
Q11	I4-Q5	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		
Q12	I3-Q2	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		
Q13	H3-P3	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		
Q14	H4-N3	Transistor, C. D. Type CH23030	4805-159855	07910	Type CH23030	REF		
Q15	F3-T4	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q16	I3-U1	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
Q17	G5-T5	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
R1	J5-Q2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R2	K1-P5	Res, comp, 47Ω ±5%, 1/4w	4704-147892	01121	EB4705	1		
R3	I3-R2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R4	H1-N5	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R5	I3-P4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R6	I5-P1	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R7	I2-R2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R8	I5-N2	Res, var, ww, 3k ±20%, 1/2w	4702-153429	71450	Type 115	REF		
R9	I1-P1	Res, met flm, 24.3k ±1%, 1/2w	4705-217430	12400	Type CEC-TO	1	1	
R10	H5-N4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R11	H5-N1	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		
R12	G5-N2	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R13	G5-P2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R14	G1-N3	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R15	F1-T5	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R16	E1-S5	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R17	F2-Q2	Res, met flm, 3.24k ±1%, 1/2w	4705-188888	12400	Type CEC-TO	1	1	
R18	G3-P5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R19	D4-P4	Res, met flm, 1k ±1%, 1/8w	4705-168229	12400	Type CEA T-O	REF		
R20	D5-P2	Res, met flm, 3.16k ±1%, 1/2w	4705-187781	12400	Type CEC T-O	1	1	
R21	B1-P2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R22	B2-N4	Res, var, ww, 3k ±20%, 1/2w	4702-153429	71450	Type 115	REF		
R23	C1-P2	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R24	B2-Q2	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R25	B1-Q1	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R26	E4-P1	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R27	D4-N5	Res, comp, 2.7k ±5%, 1/4w	4704-170720	01121	CB2725	REF		
R28	C1-P5	Res, met flm, 1k ±1%, 1/2w	4705-151324	12400	Type CEC TO	1	1	
R29	D2-U1	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R30	D2-Q2	Res, met flm, 66.5k ±1%, 1/2w	4705-187955	12400	Type CEC TO	1	1	
R31	D1-Q4	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R32	D4-R1	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R33	D5-R1	Res, comp, 2.7k ±5%, 1/4w	4704-170720	01121	CB2725	REF		
R34	D2-S5	Res, comp, 6.8k ±5%, 1/4w	4704-148098	01121	CB6825	REF		
R35	G2-P3	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R36	F5-P2	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R37	F1-N3	Res, met flm, 1k ±1%, 1/8w	4705-168229	12400	Type CEA T-O	REF		
R38	D5-P3	Res, met flm, 100Ω ±5%, 1/8w	4705-168195	12400	Type CEA T-O	REF		
R39	D4-Q1	Res, comp, 3.3k ±5%, 1/4w	4705-148056	01121	CB3325	REF		
R40	D4-P5	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R41	C5-R5	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R42	F4-T5	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R43	F1-T2	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R44	F4-S3	Res, comp, 4.7k ±5%, 1/4w	4704-148072	01121	CB4725	REF		
R45	J3-U1	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
R46	I5-U1	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R47	I4-U3	Res, comp, 680Ω ±5%, 1/4w	4704-148007	01121	CB6815	REF		
R48	H4-U1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R49	I3-T4	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R50	J1-U3	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R51	G3-T5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
S2F	G5-R1	Switch section, rotary	5107-181784	76854	253032FD	1		
TP1	J4-N2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP2	H1-N2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP3	G2-N3	Test point, yellow	2109-149138	74970	105-0757	REF		
TP4	C2-N2	Test point, green	2109-149120	74970	105-0754	REF		
TP5	C3-N2	Test point, green	2109-149120	74070	105-0754	REF		
TP6	H2-N2	Test point, black	2109-149112	74970	105-0753	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A11		**RF ENCLOSURE ASSEMBLY Figure 5-17**	3158-191924 (207-1-430)	19429	3158-191924	REF		
A35	E2-M5	Attenuator Switch Assembly (see Figure 5-17)	5110-192096	19429	5110-192096	1		
S8	F2-N4	Switch, rotary, 2p, 5 pos, 2 sect	5105-181776	19429	5105-181776	1		
XJ19	D4-U4	Connector, female, 15 contact, chassis mount	2107-183202	95354	SD615S	7		
XJ20	D5-T4	Connector, female, 15 contact, chassis mount	2107-183202	95354	SD615S	REF		
XJ21	D5-S4	Connector, female, 15 contact, chassis mount	2107-183202	95354	SD615S	REF		
XJ22	D4-R5	Connector, female, 15 contact, chassis mount	2107-183202	95354	SD615S	REF		
XJ23	D4-R2	Connector, female, 15 contact, chassis mount	2107-183202	95354	SD615S	REF		
XJ24	D4-Q3	Connector, female, 15 contact, chassis mount	2107-183202	95354	SD615S	REF		
XJ25	D4-Q1	Connector, female, 15 contact, chassis mount	2107-183202	95354	SD615S	REF		
		Card slides (not illustrated)	1407-183210	91662	#55-9016-1201	4		
A35		**ATTENUATOR SWITCH ASSEMBLY Figure 5-17**	5110-192096	19429	5110-192096	REF		
C1	J3-Q3	Cap, Ta, 0.68 uf ±10%, 35v	1508-182790	05397	K220C10K	2		
R1	J4-Q3	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	12		
R2	J5-Q4	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R3	J4-Q5	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R4	J5-R1	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R5	J5-R2	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R6	J5-R4	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R7	J5-S1	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R8	J5-S2	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R9	J5-S3	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R10	J4-S4	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R11	K1-S4	Res, comp, 27Ω ±5%, 1/4w	4704-160812	01121	CB2705	REF		
R12		Res, comp, 27Ω ±5%, 1/4w (not illustrated)	4704-160812	01121	CB2705	REF		
R13	K3-S4	Res, met flm, 36.5Ω ±1%, 1/8w	4705-168187	12400	Type CEA T-O	6	1	

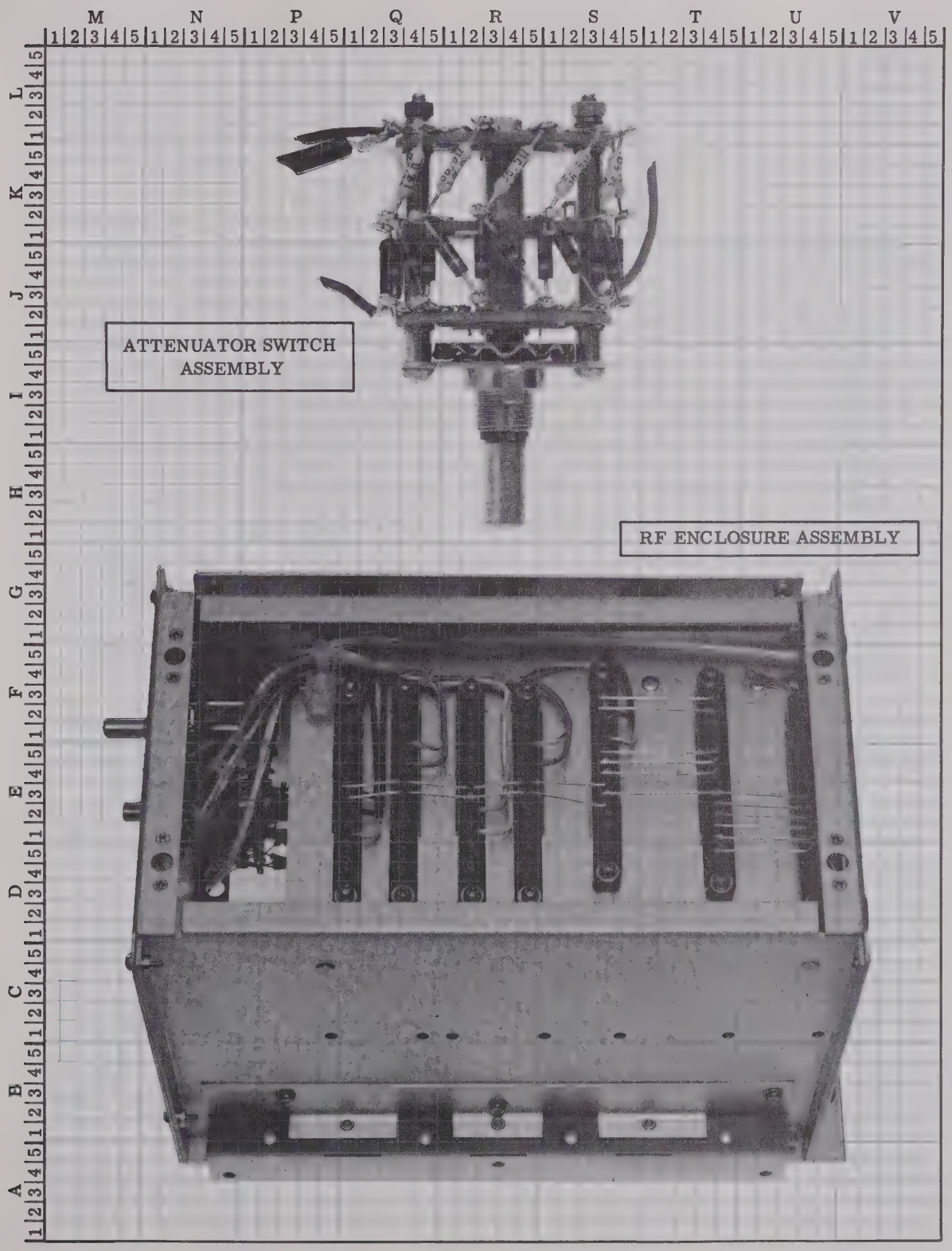


Figure 5-17. RF ENCLOSURE AND ATTENUATOR SWITCH ASSEMBLIES

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R14	K4-S4	Res, met flm, 36.5Ω ±1%, 1/8w	4705-168187	12400	Type CEA T-O	REF		
R15	K4-S2	Res, met flm, 36.5Ω ±1%, 1/8w	4705-168187	12400	Type CEA T-O	REF		
R16	K4-R4	Res, met flm, 36.5Ω ±1%, 1/8w	4705-168187	12400	Type CEA T-O	REF		
R17	K4-R1	Res, met flm, 36.5Ω ±1%, 1/8w	4705-168187	12400	Type CEA T-O	REF		
R18	K4-Q4	Res, met flm, 36.5Ω ±1%, 1/8w	4705-168187	12400	Type CEA T-O	REF		
R19		Res, comp, 1.2k ±5%, 1/4w (not illustrated)	4704-190371	01121	CB1225	1		
S7	H5-R4	Switch, rotary, 2p, 7 pos, 3 sect	5105-185777	19429	5105-185777	1		
		Card slides (not illustrated)	1407-183210	91662	55-9016-1201	14		
A12		**1.1 KHz MIXER MODULE Figure 5-18**	1702-191601 (207-1-415)	19429	1702-191601	REF		
C1	I3-N2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C2	F2-Q1	Cap, mylar, 0.1 uf ±10%, 100v	1507-168468	37942	PVC101	5		
C3	G3-Q4	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	REF		
C5	D5-N2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C6	G3-Q1	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	REF		
C8	I3-Q5	Cap, mylar, 0.01 uf ±10%, 100v	1507-168468	37942	PVC101	REF		
C9	G2-N2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C10	I2-S2	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	REF		
C11	H5-S2	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	REF		
C12	F5-R3	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C14	G4-U1	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C15	G3-S5	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C19	I4-P1	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C21	I4-U4	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C22	D3-P5	Cap, elect, 50 uf +75/-10%, 25v	1502-148650	56289	30D506G-025DD4	REF		
P19	C3-R2	Connector, male, 15 contact, chassis mount	2107-183194	95354	MDR-615B	REF		
Q1	E4-P5	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q2	E4-Q5	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q3	F5-P3	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		

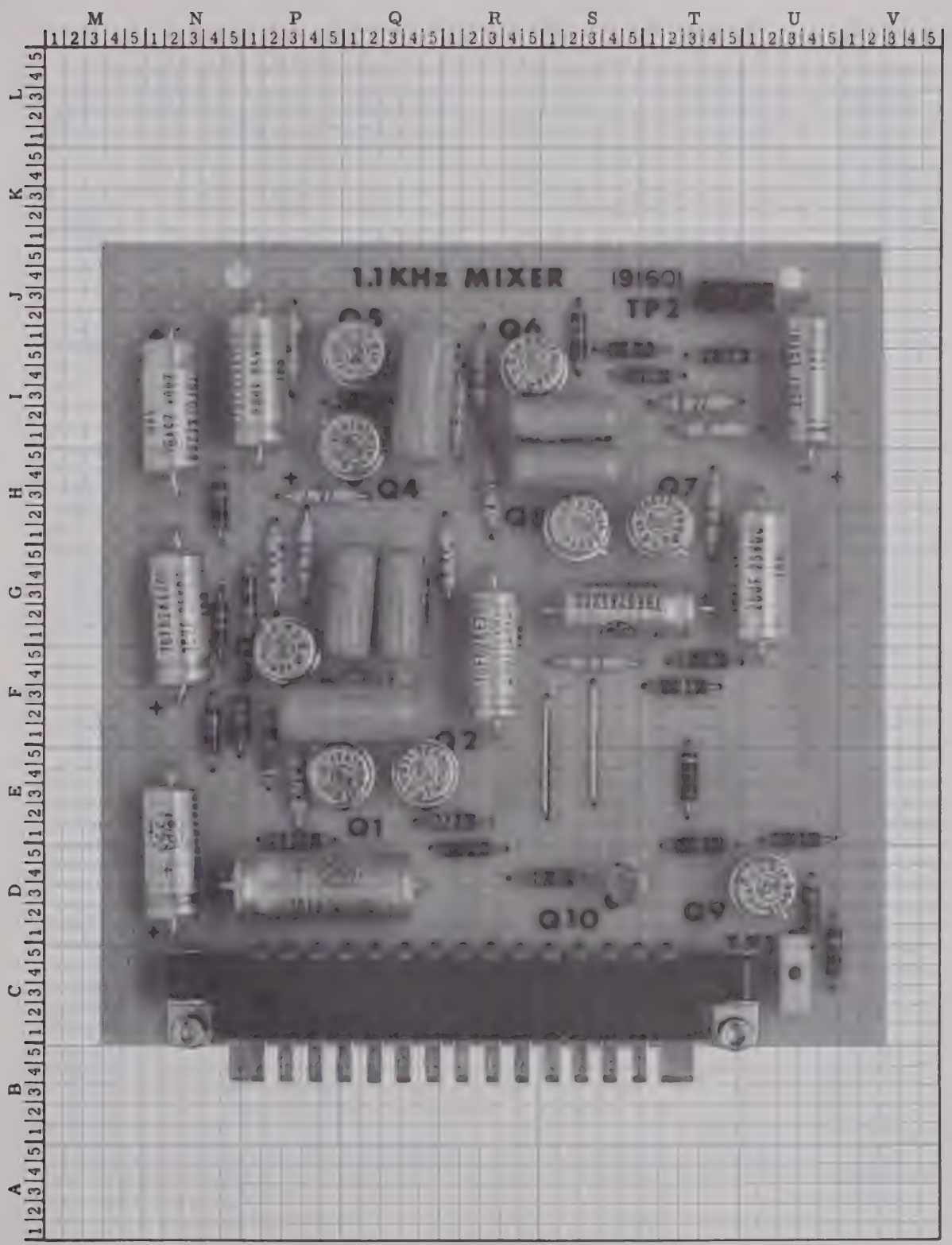


Figure 5-18. 1.1 kHz MIXER MODULE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q4	I1-Q1	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q5	I5-Q1	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q6	I5-R5	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q7	H2-T2	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q8	H1-S3	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q9	D3-U2	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q10	D3-S5	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
R1	E1-P3	Res, comp, 33k ±5%, 1/4w	4704-148155	01121	CB3335	REF		
R2	G5-P2	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R3	E3-P3	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R4	G5-P4	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R5	F4-Q2	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R6	F2-N5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R7	G1-N4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R8	F1-N4	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R9	G3-P1	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R10	E2-R1	Res, comp, 33k ±5%, 1/4w	4704-147926	01121	CB3335	REF		
R11	G3-Q5	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R12	H3-P5	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R13	G5-R1	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R14	I1-R1	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R15	J1-S2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R16	I5-S5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R17	H3-N4	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R18	I4-T1	Res, comp, 68k ±5%, 1/4w	4704-148171	01121	CB6835	REF		
R19	I3-Q1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R20	H4-R3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R21	I5-R2	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R22	J1-P3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R23	I3-T3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R24	E4-T3	Res, comp, 220Ω ±5%, 1/4w	4705-147959	01121	CB2215	REF		
R26	H3-T4	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R27	F5-T4	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		
R28	F3-T3	Res, comp, 220k ±5%, 1/4w	4704-160937	01121	CB2245	REF		
R30	F5-S3	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R31	I1-T4	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R32	E3-P3	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		A
R32	E3-P3	Res, comp, 470Ω ±5%, 1/4w	4704-147983	01121	CB4715	REF		B
R33	D2-U4	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R34	I5-T5	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R35	E1-U3	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R36	E1-T4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R37	C5-U5	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R38	D4-S1	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R40	D5-R2	Res, comp, 120Ω ±5%, 1/4w	4704-170712	01121	CB1215	REF		
TP1	C3-U3	Test point, yellow	2109-149138	74970	105-0757	REF		
TP2	J3-T5	Test point, black	2109-149112	74970	105-0753	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		
A13		**51.1 KHz MIXER MODULE Figure 5-19**	1702-191619 (207-1-416)	19429	1702-191619	REF		
C1	F1-T4	Cap, mylar, 0.1 uf ±10%, 100v	1507-168468	37942	PVC101	REF		
C2	H2-T5	Cap, mylar, 0.0047 uf ±10%, 400v	1507-182162	37942	PVC4247	2		
C3	H1-U4	Cap, mylar, 0.0047 uf ±10%, 400v	1507-182162	37942	PVC4247	REF		
C4	H4-U1	Cap, mica, 430 pf ±5%, 500v	1504-177980	88419	CD19F431J	6		
C5	I1-U4	Cap, mica, 430 pf ±5%, 500v	1504-177980	88419	CD19F431J	REF		
C6	I3-U1	Cap, mica, 1,300 pf ±5%, 500v	1504-182881	88419	CD19F132J	2		
C7	I5-U1	Cap, mica, 1,300 pf ±5%, 500v	1504-182881	88419	CD19F132J	REF		
C8	I4-S1	Cap, mica, 430 pf ±5%, 500v	1504-177980	88419	CD19F431J	REF		
C9	J2-U1	Cap, mica, 430 pf ±5%, 500v	1504-177980	88419	CD19F431J	REF		
C10	E1-R1	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C11	H1-S3	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C12	H5-Q2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C13	I3-R2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C14	G4-R2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C16	F4-P1	Cap, plstc, 0.0047 uf ±2%, 100v	1507-182972	84171	PE-472-G	2	1	
C17	F2-P1	Cap, mica, 33 pf ±5%, 500v	1504-160317	88419	CD15F330J	REF		
C18	E4-P3	Cap, plstc, 0.0047 uf ±2%, 100v	1507-182972	84171	PE-472-G	REF		
C19	I5-P1	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C20	F5-Q3	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
L1	I2-T3	Inductor, 15 mh, 49 ma	1801-182964	72559	WEE-15,000	4	1	
L2	I3-S5	Inductor, 15 mh, 49 ma	1801-182964	72559	WEE-15,000	REF		
L3	I5-U5	Inductor, 15 mh, 49 ma	1801-182964	72559	WEE-15,000	REF		
L4	J4-T4	Inductor, 15 mh, 49 ma	1801-182964	72559	WEE-15,000	REF		
P20	C3-R4	Connector, male, 15 contact, chassis mount	2107-183194	95354	MDR-615B	REF		

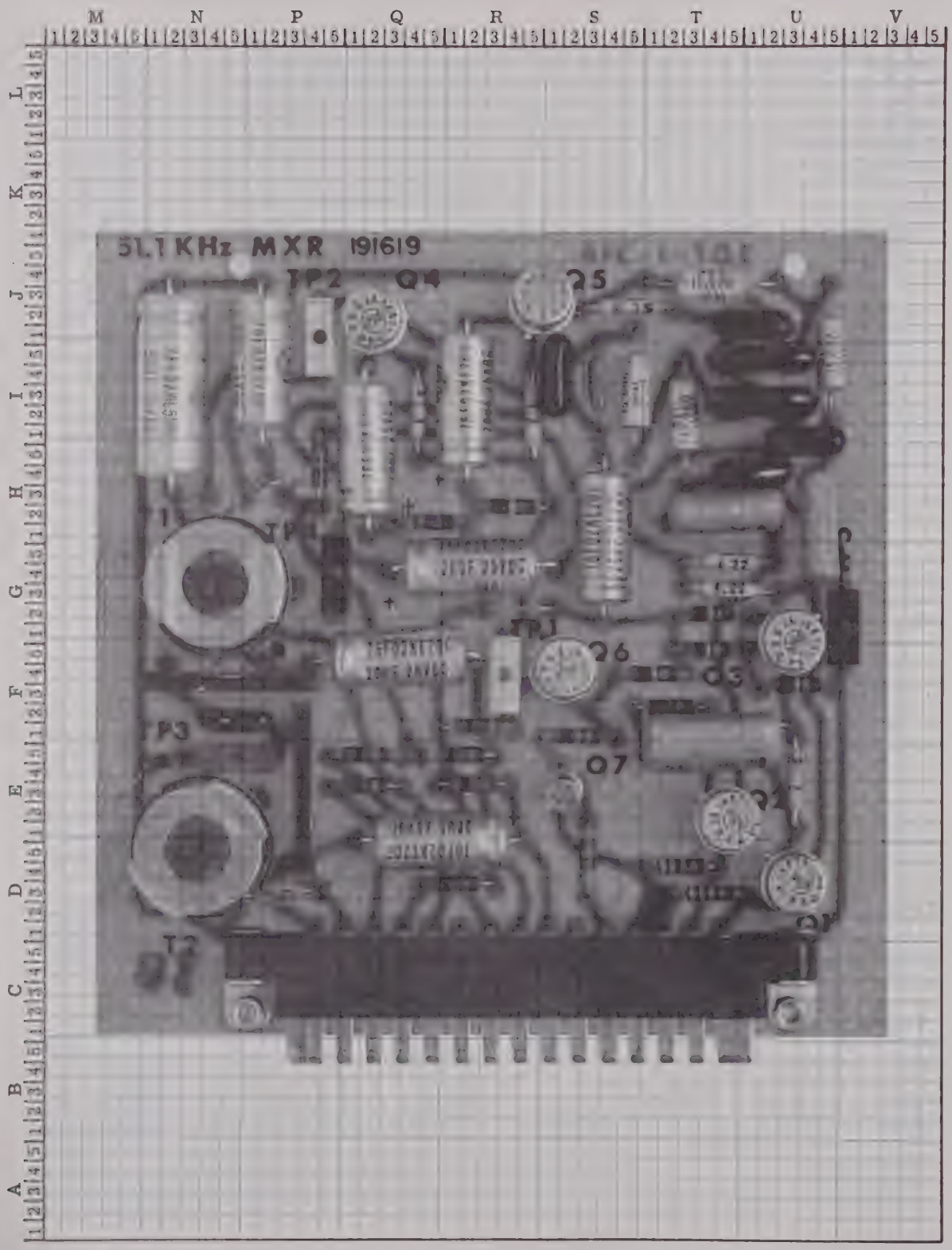


Figure 5-19. 51.1 kHz MIXER MODULE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
Q1	D3-U3	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q2	E2-T5	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q3	G1-U3	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q4	J2-Q2	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q5	J3-S1	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q6	F4-S2	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q7	E3-S2	Transistor, Type 2N706A	4805-148593	01295	Type 2N706A	REF		
R1	H5-P4	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R2	G3-T5	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R3	G5-T5	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R4	E4-U3	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R5	F2-T2	Res, comp, 220Ω ±5%, 1/4w	4704-147959	01121	CB2215	REF		
R6		Res, met flm, 2.1k ±1%, 1/8w (not illustrated, between C1 and R5)	4705-168237	12400	Type CEA T-O	REF		
R7	G2-T4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R8	F4-T4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R9	F3-U4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R10	D3-T4	Res, comp, 33k ±5%, 1/4w	4704-148155	01121	CB3335	REF		
R11	D4-T3	Res, comp, 33k ±5%, 1/4w	4704-148155	01121	CB3335	REF		
R12	E3-R2	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R13	I4-S3	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R14	I2-Q4	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R15	H2-Q5	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R16	H2-R4	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		A
R16	H2-R4	Res, comp, 220k ±5%, 1/4w	4704-160937	01121	CB2245	REF		B
R17	I2-R5	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R18	J3-S5	Res, met flm, 4.22k ±1%, 1/8w	4705-168245	12400	Type CEA T-O	REF		
R19	F1-S2	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R20	F1-R3	Res, comp, 1k ±5%, 1/4w	4704-148023	01121	CB1025	REF		
R21	F4-T1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R23	D3-R1	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R24	E3-Q2	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R25	E5-R2	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R26	E3-Q1	Res, comp, 120Ω ±5%, 1/4w	4704-170712	01121	CB1215	REF		
R27	D5-S3	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
T1	G3-N4	Transformer, var	1800-191973	19429	1800-191973	2	1	
T2	D5-N4	Transformer, var	1800-191973	19429	1800-191973	REF		
TP1	F4-R4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP2	J1-P4	Test point, yellow	2109-149138	74970	105-0757	REF		
TP3	E5-P1	Test point, green	2109-149120	74970	105-0754	REF		
TP4	G3-P5	Test point, black	2109-149112	74970	105-0753	REF		
TP5	G1-V1	Test point, black	2109-149112	74970	105-0753	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A14		**BROAD BAND RF AMPLIFIER MODULE - Figure 5-20**	1702-191627 (207-1-417)	194627	1702-191627	1		
C1	D4-Q5	Cap, mylar, 0.68 uf ±10%, 100v	1507-182139	37942	PVC1068	1		
C2	G1-N4	Cap, poly, 0.0033 uf ±2%, 100v	1507-168344	84171	PE-332-G	2	1	
C3	H1-N4	Cap, poly, 0.0033 uf ±2%, 100v	1507-168344	84171	PE-332-G	REF		
C4	F2-P4	Cap, mylar, 0.1 uf ±10%, 100v	1507-168468	37942	PVC101	REF		
C5	F1-Q4	Cap, mylar, 0.1 uf ±10%, 100v	1507-168468	37942	PVC101	REF		
C6	F3-N5	Cap, mylar, 0.047 uf ±10%, 100v	1507-183269	37942	PVC1147	2		
C7	H2-S1	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C8	H4-N5	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C9	J1-N5	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C10	E4-S2	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C11	J3-Q3	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C12	F4-R1	Cap, mylar, 0.047 uf ±10%, 100v	1507-183269	37942	PVC1147	REF		
C13	G5-S5	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C14	I2-S1	Cap, mylar, 0.015 uf ±10%, 200v	1507-182154	37942	PVC2115	1		
C15	I4-S1	Cap, mica, 430 pf ±5%, 500v	1504-177980	88419	CD19F431J	REF		
C16	J3-S3	Cap, mica, 5,600 pf ±2%, 500v	1504-182873	88419	CD19F562G	2		
C17	J1-U5	Cap, mica, 1,000 pf ±5%, 500v	1504-148387	88419	CD19F102J	REF		
C18	I1-T5	Cap, mica, 5,600 pf ±2%, 500v	1504-182873	88419	CD10F562G	REF		
C19	H5-U5	Cap, mica, 430 pf ±5%, 500v	1504-177980	88419	CD19F431J	REF		
C20	D3-T1	Cap, elect, 20 uf +75/10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C21	F1-U1	Cap, elect, 20 uf +75/-10%, 25v	1502-148817	56289	30D206G-025DB4	REF		
C22	I5-Q5	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	REF		
C23	G3-N2	Cap, mica, 22 pf ±5%, 500v	1504-148851	88419	CD15E220J	1		
L1	E2-Q3	Inductor, 390 uh, 230 ma	1801-186288	72559	WEE-390	1	1	
L2	E4-Q3	Inductor, 270 uh, 260 ma	1801-186270	72559	WEE-270	1	1	
L4	J1-T5	Inductor, var, 1.8 mh	1800-191965	19429	1800-191965	2	1	
L5	G5-U3	Inductor, var, 1.8 mh	1800-191965	19429	1800-191965	REF		
P21	C4-R5	Connector, male, 15 contact, chassis mount	2107-183194	95354	MDR-615B	REF		
Q1	F5-R5	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q2	I1-Q2	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
Q3	H5-R2	Transistor, Type 2N396A	4805-148585	95303	Type 2N396A	REF		
R1	G2-R4	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R3	F4-S4	Res, comp, 2.2k ±5%, 1/4w	4704-148049	01121	CB2225	REF		

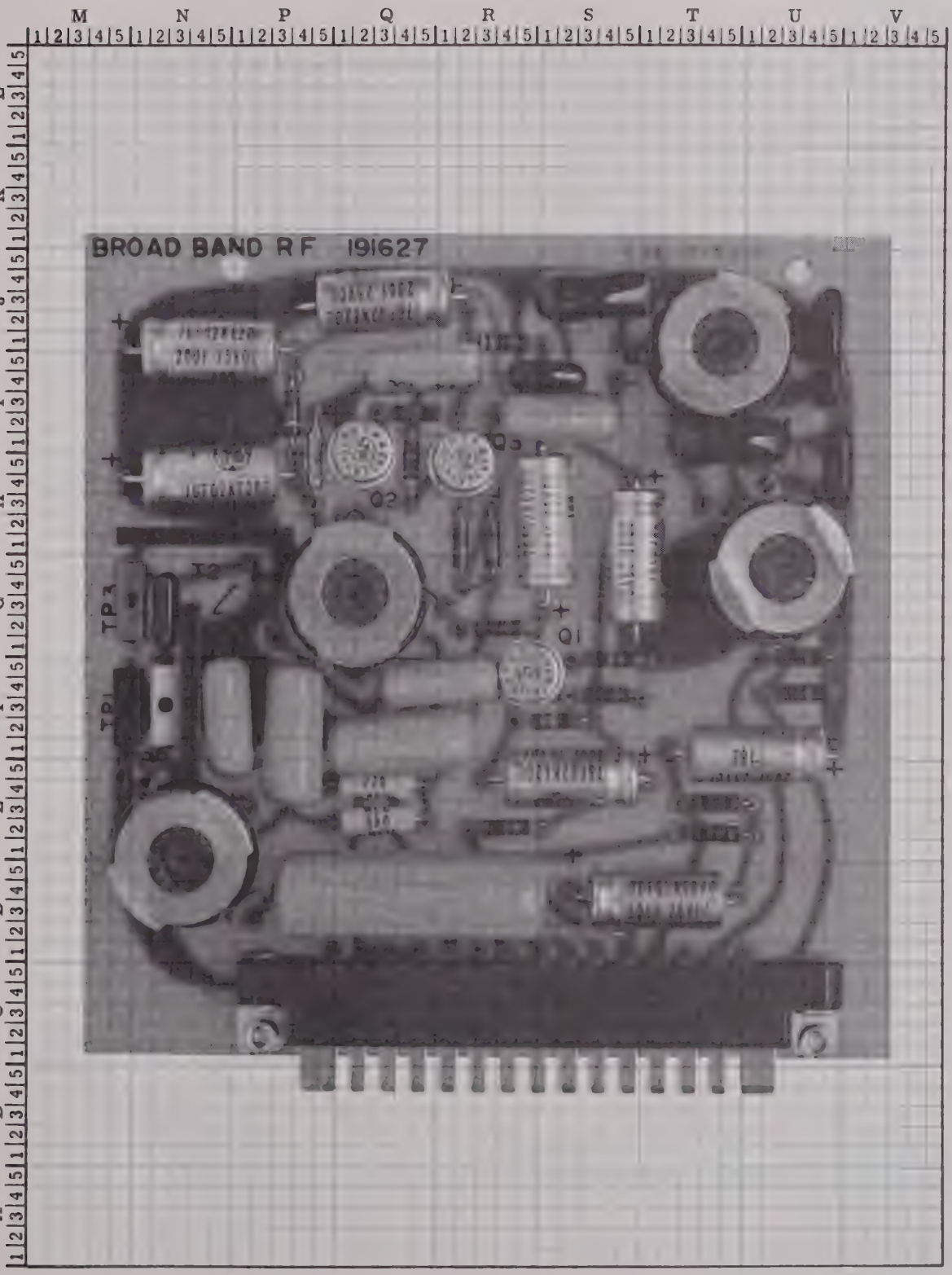


Figure 5-20. RF BROADBAND AMPLIFIER MODULE

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
R5	F2-S1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R6	H5-P5	Res, met flm, 2.1k ±1%, 1/8w	4705-168237	12400	Type CEA T-O	REF		
R7	F5-S4	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R8	I3-Q5	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R9	H1-R2	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R10	H5-Q4	Res, comp, 330Ω ±5%, 1/4w	4704-147967	01121	CB3315	REF		
R11	J1-R4	Res, comp, 3.3k ±5%, 1/4w	4704-148056	01121	CB3325	REF		
R13	E2-R4	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R14	E2-T5	Res, comp, 120Ω ±5%, 1/4w	4704-170712	01121	CB1215	REF		
R15	E3-T5	Res, comp, 120Ω ±5%, 1/4w	4704-170712	01121	CB1215	REF		
R16	G1-U4	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R17	F4-U4	Res, comp, 1.5k ±5%, 1/4w	4704-148031	01121	CB1525	REF		
R18	I3-P3	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
R19	H1-R3	Res, comp, 100Ω ±5%, 1/4w	4704-147926	01121	CB1015	REF		
T1	E1-N3	Transformer, var	1800-192054	19429	1800-192054	2	1	
T2	G4-Q1	Transformer, var	1800-192054	19429	1800-192054	REF		
TP1	F3-M5	Test point, black	2109-149112	74970	105-0753	REF		
TP2	F3-N2	Test point, yellow	2109-149138	74970	105-0757	REF		
TP3	G3-M5	Test point, green	2109-149120	74970	105-0754	REF		
		Transipad for TO-5 transistor (not illustrated)	3155-152207	17069	88000	REF		
A16		**STRIP CHART RECORDER** Figure 5-21	4301-179608	14869	Model 88	REF		
		The following parts listing is included for reference only. Replacement parts for the Strip Chart Recorder are not normally stocked at Montronics Inc. For fastest possible service, order parts directly from Rustrak Instrument Co., Inc., 130 Silver St. Manchester, N.H. or their authorized representatives. However, questions concerning in-warranty repairs should always be directed to Montronics Inc.						
	1	Panel Assembly, basic		14869	SA-1239			
	2	Button, plug		14869	BS-48151			
	3	Screw, front panel		14869	A-2208			
	4	Ring, retaining		14869	WA-512			
	5	Washer, internal lock		14869	L1-2			
	6	Screw, Bind. Hd. S. Stl.		14869	2-56 x 1/8			
	7	Spring, striker		14869	A-2225			
	8	Left side plate, sub-assembly		14869	SA-1235			
	9	Screw, Bind. Hd. S. Stl.		14869	5-40 x 3/8			
	10	Gear		14869	2-2232			

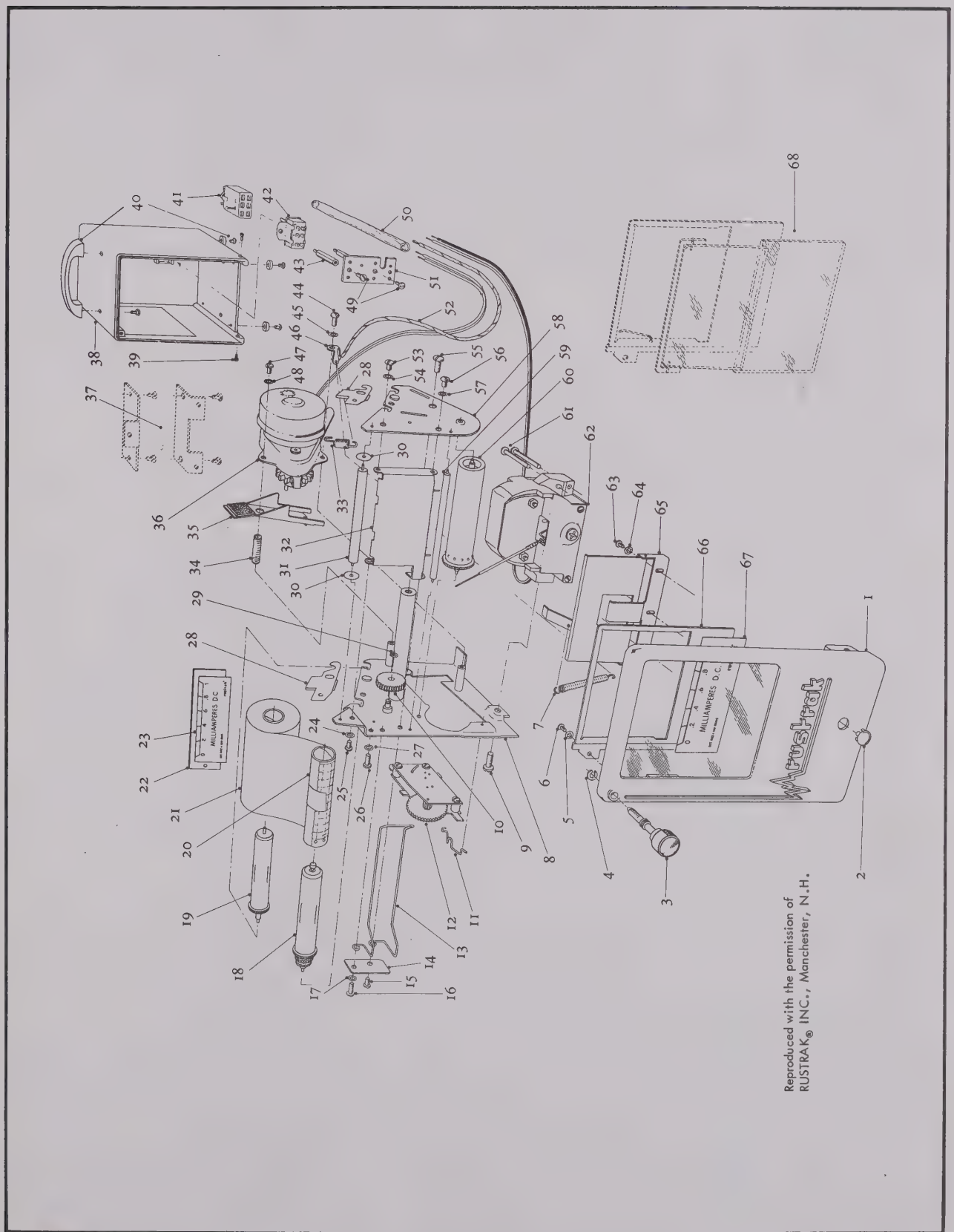


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Figure 5-21. STRIP CHART RECORDER

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
	11	Spring, gear box		14869	A-2354			
	12	Gear box		14869	1			
	13	Guard, pointer		14869	B-3029			
	14	Plate, spring		14869	A-3061			
	15	Screw, Bind. Hd. S. Stl.		14869	4-40 x 1/4			
	16	Screw, Bind. Hd. S. Stl.		14869	4-40 x 5/16			
	17	Washer, internal lock		14869	L1-4			
	18	Roller, reroll complete		14869	SA-1242			
	19	Roller, supply		14869	B-2316-2			
	20	Spool, paper		14869	A-2254			
	21	Paper, strip chart	3001-951301	14869	1		3	
	22	Plate, scale		14869	A-2289			
	23	Scale, decal		14869	1			
	24	Washer, internal lock		14869	L1-4			
	25	Screw, Bind. Hd. S. Stl.		14869	4-40 x 3/16			
	26	Screw, Bind. Hd. S. Stl.		14869	4-40 x 5/16			
	27	Washer, internal lock		14869	L1-4			
	28	Clip, paper roll		14869	B-2348			
	29	Ring, retaining		14869	5100-18-C-MF			
	30	Washer, flat (top roller)		14869	138-343-025			
	31	Roller, top		14869	A-2406			
	32	Plate, back up & spring		14869	B-2474 & A-2475			
	33	Spring, actuator		14869	A-2303			
	34	Spring, brake		14869	A-2312			
	35	Brake Assembly		14869	SA-1192			
	36	Motor Assembly		14869	1			
		Cam, Motor		14869	B-2476			
	37	Panel mtg. hardware		14869	SA-1246			
	38	Case Assembly		14869	SA-1241			
	39	Screw, hinge		14869	4-40 x 3/16			
	40	Portable hardware		14869	SA-1245			
	41	Socket		14869	S-306-CCT			
	42	Plug		14869	P-306-AB			
	43	Spacer		14869	A-2229			
	44	Spacer, Bind. Hd. S. Stl.		14869	4-40 x 1/4			
	45	Washer, internal lock		14869	L1-4			
	46	Lug, dual		14869	123-6			
	47	Screw, Bind. Hd. S. Stl.		14869	4-40 x 1/4			
	48	Washer, internal lock		14869	L1-4			
	49	Screw, Bind. Hd. S. Stl.		14869	6-32 x 1/4			
	50	Sleeving		14869	3			
	51	Board		14869	B-2456			
	52	Wire		14869	22			
	53	Screw, Bind. Hd. S. Stl.		14869	4-40 x 3/16			
	54	Washer, internal lock		14869	L1-4			
	55	Screw, Bind. Hd. S. Stl.		14869	10-32 x 5/16			
	56	Screw, Bind. Hd. S. Stl.		14869	4-40 x 3/16			
	57	Washer, internal lock		14869	L1-4			

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
	58	Plate R. H.		14869	C-2217			
	59	Roller, center		14869	A-2203			
	60	Roller Assembly, Time drum		14869	SA-1190			
	61	Screw, Bind. Hd. S. Stl.		14869	4-40 x 5/8			
	62	Meter Assembly		14869	[1]			
		Pointer Assembly (meter)		14869	[1]			
	63	Screw, Bind. Hd. S. Stl.		14869	2-56 x 1/8			
	64	Washer, internal lock		14869	L1-2			
	65	Striker & Bracket Assembly		14869	A-2213 & A-2214			
	66	Bezel		14869	A-2221			
	67	Scale, same as item #23		14869	[1]			
	68	Access window kit		14869	A-2931			

[1] For items without a part number, please specify model number and describe.

A17		**OPTIONAL BATTERY PACK** **Figure 5-22** (207-4B, -5B only)	207-4B-499	19429	207-4B-499			
BT1	E2-Q4	Battery, 1.2v, Nickel-Cadium (20 batteries in pack, one located)	4002-160390	06860	1.2SC			
	H2-M4	Bracket Mounting	207-4B-203	19429	207-4B-203			
	I5-T2	Bracket Mounting	207-4B-203	19429	207-4B-203			
	G1-T1	Bracket Side	207-4B-205	19429	207-4B-205			
	E2-T1	Bracket Side	207-4B-205	19429	207-4B-205			
	I3-Q4	Insulator	207-4B-206	19429	207-4B-206			
	D1-Q4	Insulator	207-4B-206	19429	207-4B-206			

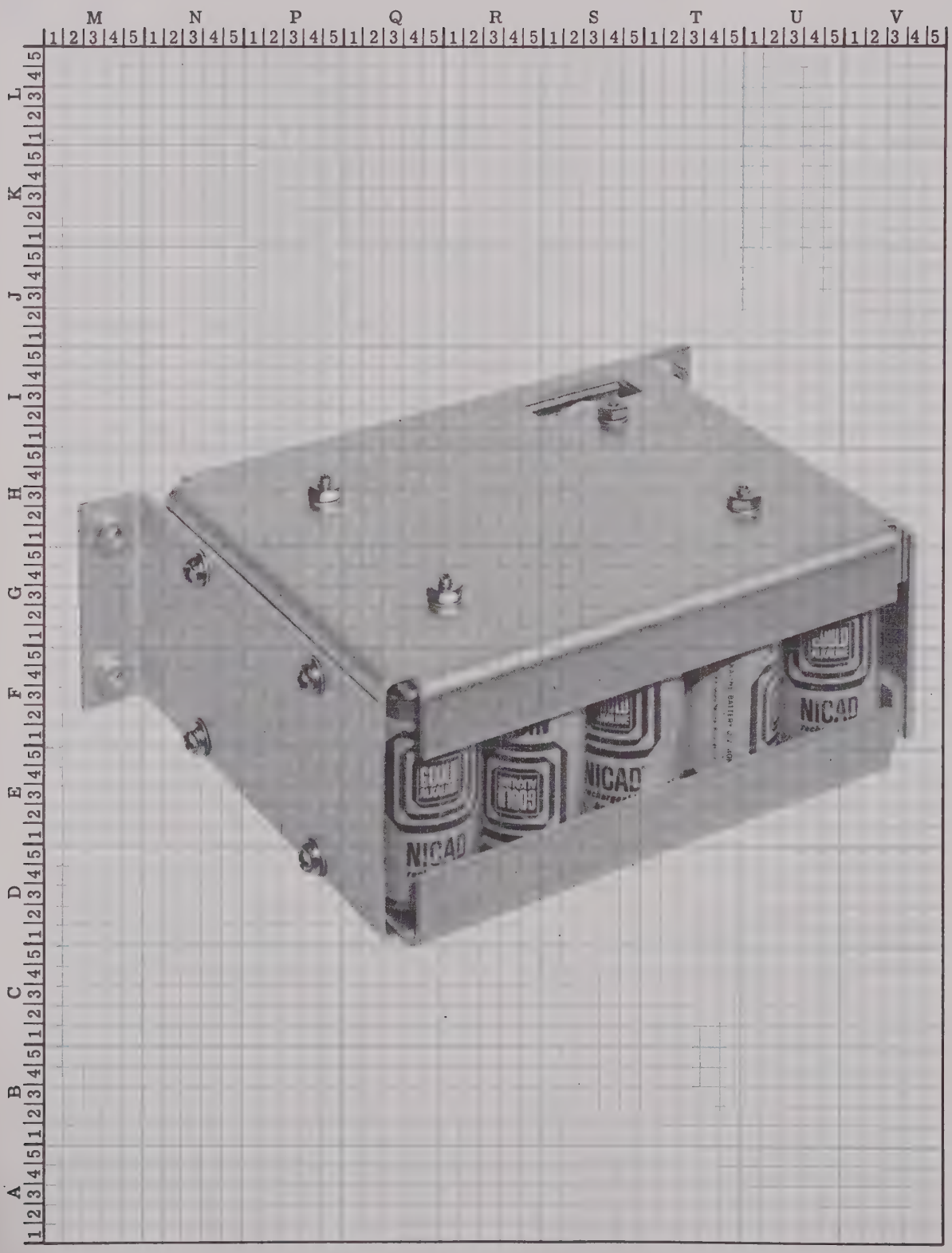


Figure 5-22. OPTIONAL BATTERY PACK

REF DESIG	INDEX NO	DESCRIPTION	STOCK NO	MFR	MFR PART NO	TOT QTY	REC QTY	USE CODE
A18		**WHIP ANTENNA ASSEMBLY Figure 5-23**	1200-191908 (207-1-450)	19429	1200-191908	REF		
A36		Antenna Base (See Figure 5-23)	1200-191916 (207-1-451)	19429	1200-191916	1		
		Whip Antenna (not illustrated)	1200-170332	97540	100-103S	1		
		Cable (not illustrated)	6002-164665	19429	6002-164665	1		
A36		**ANTENNA BASE - Figure 5-23**	1200-191916 (207-1-450)	19429	1200-191916	REF		
A37	L1-R3	Antenna Matching Network (See Figure 5-23)	1702-191650 (207-1-420)	19429	1702-191650	1		
J28	D1-Q4	Connector, female, Type BNC	2106-152033	02660	UG 1094/U	REF		
		Mounting Kit (not illustrated)	1200-170340	97540	CS 111	1		
A37		**ANTENNA MATCHING NETWORK - Figure 5-23**	1702-191650 (207-1-420)	19429	1702-191650	REF		
C1	J2-S3	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	REF		
C2	I2-R4	Cap, mylar, 0.01 uf ±10%, 200v	1507-168450	37942	PVC211	REF		
C3	K1-Q4	Cap, Ta, 3.3 uf ±10%, 15v	1508-182808	05397	K3R3C15K	REF		
C4	K4-R3	Cap, mylar, 0.047 uf ±10%, 100v	1507-183269	37942	PVC1147	REF		
Q1	J3-R4	Transistor, Kemet Type F-1047	4805-166223	05397	Type F-1047	REF		
R1	I5-S1	Res, comp, 10k ±5%, 1/4w	4704-148106	01121	CB1035	REF		
R2	I4-R5	Res, comp, 1.5M ±5%, 1/4w	4704-182857	01121	CB1555	REF		
R3	I5-R1	Res, comp, 1M ±5%, 1/4w	4704-182204	01121	CB1055	REF		
R4	J2-Q5	Res, comp, 270Ω ±5%, 1/4w	4704-160804	01121	CB2715	1		
A19		**ACCESSORY KIT - Figure 5-24**	3001-191866 (207-1-445)	19429	3001-191866	REF		
	E4-T4	Card Puller	3156-170951	19429	3156-170951	2		
	E4-V1	Card Puller	3156-170951	19429	3156-170951	REF		
	G4-U2	Plastic Overlay	2506-188359	19429	2506-188359	1		
	L1-P5	Riser Card, 15 pin	1702-191668 (207-1-421)	19429	1702-191668	1		
	H5-P5	Riser Card, 22 pin	1702-165506 (302-410)	19429	1702-165506	1		
	D5-P5	Shorting Jumper	6002-164707	19429	6002-164707	2		
	C4-P5	Shorting Jumper	6002-164707	19429	6002-164707	REF		
	D3-T5	Tool, adjustment	5402-153049	73899	5284	1		
	B5-T5	Tool, adjustment	5402-178814	02114	DT-2168	1		

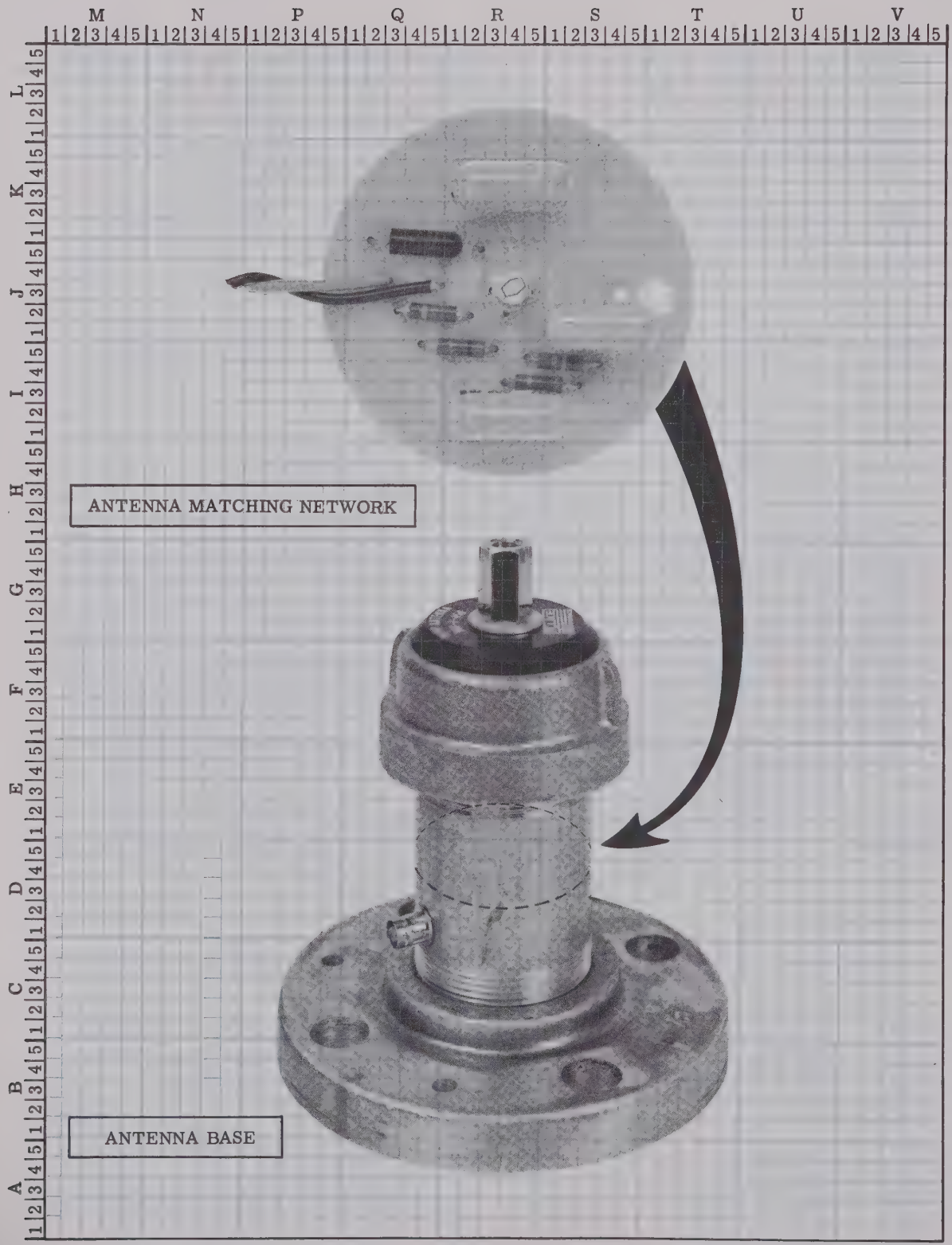


Figure 5-23. WHIP ANTENNA ASSEMBLY

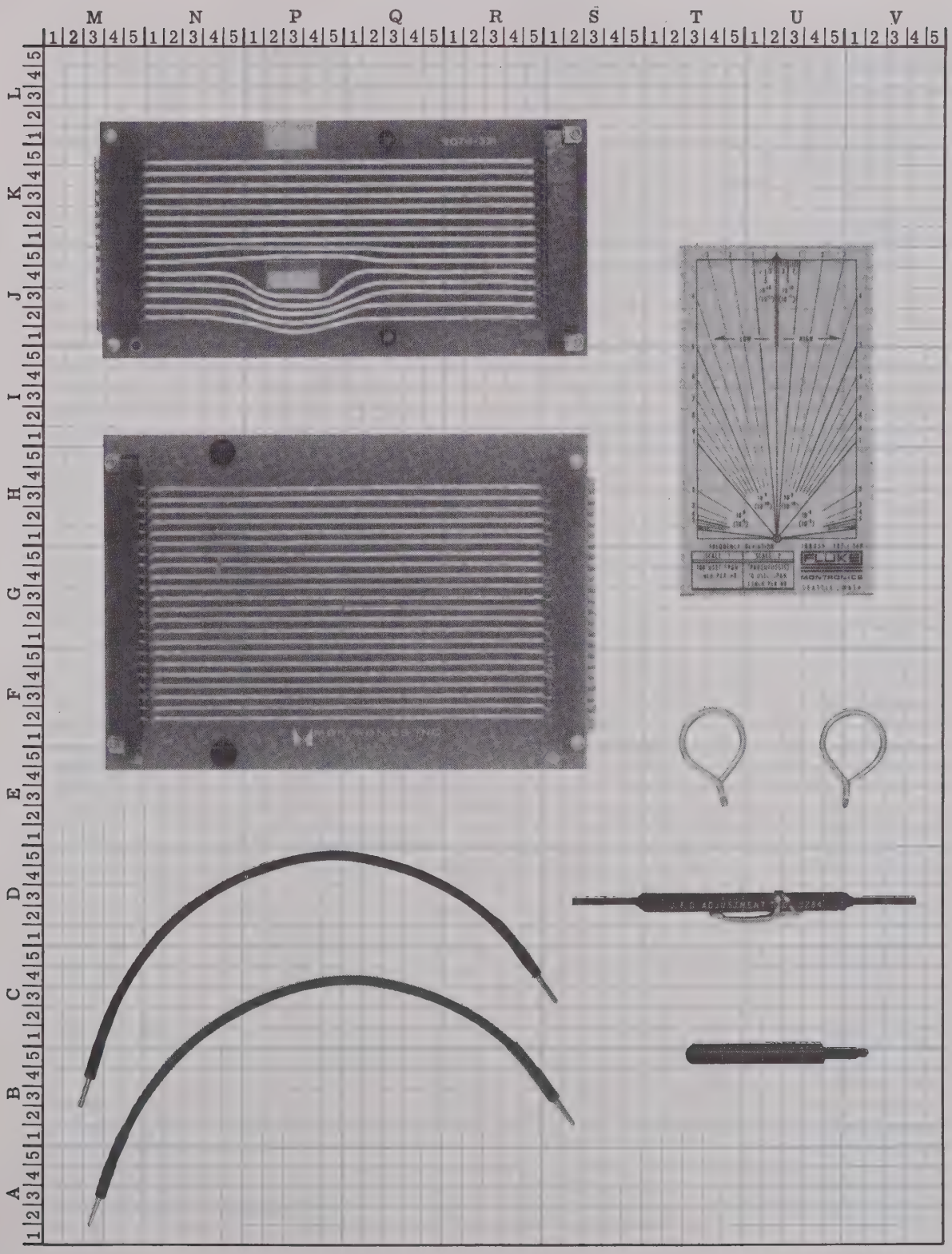


Figure 5-24. ACCESSORY KIT

5-8. SERIAL NUMBER EFFECTIVITY

5-9. Use Code column is provided to identify certain parts that have been added, deleted or modified during the production of the Model 207. Each part for which a use code has been assigned may be identified with a particular instrument serial number by consulting the list below. Parts having no code are used in instruments with serial numbers above 112.

USE CODE	EFFECTIVITY
A	All models; approx. S/N 112 to 140.
B	All models; approx. S/N 141 and on.
C	All models; approx. S/N 112 to 157.
D	All models; approx. S/N 158 and on.
E	All models; approx. S/N 112 to 148.
F	All models; approx. S/N 149 and on.

APPENDIX A

FEDERAL SUPPLY CODE FOR MANUFACTURERS

CODE TO NAME

To conserve space, component manufacturers are listed in the parts list of this manual by a five-digit code. The code number is the Federal Supply Code for Manufacturers as listed in the Department of Defense Cataloguing Handbook H 4-2. In the list below, the code numbers are listed in numerical sequence for easy reference.

00213 Sage Electronics Corp.
Rochester, New York

00327 Welwyn International, Inc.
Cleveland, Ohio

00656 Aerovox Corp.
New Bedford, Massachusetts

01121 Allen-Bradley Company
Milwaukee, Wisconsin

01281 Pacific Semiconductors Inc.
Lawndale, California

01295 Texas Instruments, Inc.
Semiconductor Components Div.
Houston, Texas

01730 Circle Mfg. Co., Inc.
Little Falls, New Jersey

01884 Dearborn Electronic Labs Inc.
Orlando, Florida

01963 Cherry Electrical Products Corp.
Highland Park, Illinois

02214 Ferroxcuby
Saugerties, New York

02660 Amphenol-Borg Elect. Corp
Chicago, Illinois

02606 Fenwal Laboratories Inc.
Framington, Massachusetts

02799 Arco Capacitors, Inc.
Los Angeles, California

03614 Bussmann Mfg. Div. of
McGraw-Edison Co.
Los Angeles, California

03615 Ohmite Mfg. Company
Los Angeles, California

03877 Transitron Electronic Corp.
Wakefield, Massachusetts

03911 Clairex Corp.
New York, New York

03980 Muirhead Instruments, Inc.
Mountainside, New Jersey

04009 Arrow Hart and Hegemen
Electronic Company
Hartford, Connecticut

04062 Elmenco Products Company
New York, New York

04202 Winchester Electronics Co.
New Milford, Connecticut

04221 Telex-Aemco Division
of Telex Corp.
Mankato, Minnesota

04645 Kurz-Kasch, Inc.
Chicago, Illinois

04713 Moforola Inc.
Semiconductor Products Div.
Phoenix, Arizona

05082 Tung-Sol Electric Inc.
Melrose Park, Illinois

05277 Westinghouse Electric Corp.
Semiconductor Dept.
Youngwood, Pennsylvania

05278 Penn-East Engrg. Corp.
Kutztown, Pennsylvania

05397 Union Carbide Corp.
Kemet Dept. Linde Div.
Cleveland, Ohio

05617 Farwest Mfg. Div. Inc.
Seattle, Washington

05704 Alac, Inc.
Glendale, California

05820 Wakefield Engineering, Inc.
Wakefield, Massachusetts

06001 General Electric Company
Capacitor Department
Irmo, South Carolina

06136 Ward Leonard Electric Co.
Los Angeles, California

06473 Amphenol Space and Missile Sys
Chatsworth, California

06555 Beede Electrical Inst. Co.
Penacook, New Hampshire

06751 Nuclear Corporation of
American, Inc.
U.S. Semcor Div.
Phoenix, Arizona

06860 Gould National Batteries Inc.
La Puente, California

07115 Corning Glass Works
Electronic Components Dept.
Bradford, Pennsylvania

07263 Fairchild Semiconductor
Div. of Fairchild Camera
and Instrument Corp.
Mountain View, California

07344 Bircher Co., Inc.
Rochester, New York

07792 Lerma Engineering Corp.
Northampton, Massachusetts

07910 Continental Device Corp.
Hawthorne, California

08530 Reliance Mica Corp.
Brooklyn, New York

08863 Nylomatic Corp.
Morrisville, Pennsylvania

08988 Skottie Electronics Inc.
Peckville, Pennsylvania

11237 Chicago Telephone of Calif Inc.
South Pasadena, California

11503 Keystone Mfg. Co.
Warren, Michigan

12040 National Semiconductor, Inc.
Danburry, Connecticut

12060 Diodes, Inc.
Chatsworth, California

12136 Philadelphia Handle Co.
Camden, New Jersey

12323 Presin Co., Inc.
Santa Monica, California

12400 International Resistance Co.
Control Components Division
Philadelphia, Pennsylvania

12617 Hamlin Inc.
Lake Mills, Wisconsin

12697 Clarostat Mfg. Company
Dover, New Hampshire

13606 Sprague Electric Company
Transistor Division
Concord, New Hampshire

13812 Dialco Electric Corp.
Brooklyn, New York

13839 Sulzer Lab, Inc.
Bethesda, Maryland

14099 Semtech Corp.
Newbury Park, California

14193 California Resistor Corp.
Santa Monica, California

14298 American Components Inc.
Conshohocken, Pennsylvania

14752 Electro Cude Inc.
South Pasadena, California

14869 Rustrak Instrument Co.
Manchester, New Hampshire

15818 Amelco Inc.
Mountain View, California

15849 USECO Inc.
Mt. Vernon, New York

15909 Daven Division
Thomas A. Edison Ind.
McGraw Edison Co.
Livingston, New Jersey

16332 Milwaukee Relays Inc.
Cedarburg, Wisconsin

16473 Cambridge Scientific
Industries Inc.
Cambridge, Maryland

16742 Paramount Plastics
Downey, California

17069 Circuit Structures Lab
Santa Ana, California

17856 Siliconix Inc.
Sunnyvale, California

18083 Clevite Corp.
Transistor Division
Palo Alto, California

19429 Montronics, Inc.
Seattle, Washington

19701 Electra Mfg. Company
Independence, Kansas

24655 General Radio Company
West Concord, Massachusetts

28520 Heyman Mfg. Company
Kenilworth, New Jersey

33173 General Electric Co.
Tube Dept.
Owensboro, Kentucky

37942 P.R. Mallory and Co., Inc.
Indianapolis, Indiana

38315 Honeywell Inc.
Precision Meter Division
Manchester, New Hampshire

42498 National Company, Inc.
Malden, Massachusetts

44655 Ohmite Mfg. Company
Skokie, Illinois

49671 Radio Corp. of America
New York, New York

53021 Sangamo Electric Co.
Springfield, Illinois

55026 Simpson Electric Company
Chicago, Illinois

56289 Sprague Electric Co.
North Adams, Massachusetts

58474 Superior Electric Co.
Bristol, Connecticut

60399 Torrington Mfg. Company
Torrington, Connecticut

62460 USHCO Mfg. Co., Inc.
Buffalo, New York

64834 West Mfg. Company
San Francisco, California

65092 Weston Instruments
Div. of Daystrom, Inc.
Newark, New Jersey

66150 Winslow Tele-Tronics Inc.
Asbury Park, New Jersey

70563 Amperite Company
Union City, New Jersey

70903 Belden Mfg. Co.
Chicago, Illinois

71400 Bussman Manufacturing
Division of McGraw Edison Co.
St. Louis, Missouri

71450 CTS Corp.
Elkhart, Indiana

71468 Cannon Electric Company
Los Angeles, California

71482 Clare, C. P. and Company
Chicago, Illinois

71590 Centralab Div of
Globe Union, Inc.
Milwaukee, Wisconsin

71707 Coto Coil Co., Inc.
Providence, Rhode Island

71744 Chicago Miniature Lamp
Works
Chicago, Illinois

71785 Cinch Mfg. Co. and
Howard B. Jones Div.
Chicago, Illinois

72005 Driver, Wiber B., Co.
Newark, New Jersey

72092 Eitel-McCullough, Inc.
San Bruno, California

72136 Electro Motive Mfg. Co.
Willimantic, Connecticut

72259 Nytronics, Inc.
Berkley Heights,
New Jersey

72354 Fast, John E. Company
Div. of Victoreen Instr. Co.
Chicago, Illinois

72559 Essex Electronics Inc.
Berkeley Heights,
New Jersey

72619 Dialight Corp.
Brooklyn, New York

72653 General Cement Div.
of Titronics Inc.
Packard, Illinois

72665 Mallory Battery Company
Cleveland, Ohio

72982 Erie Tech. Products Inc.
Erie, Pennsylvania

73138 Beckman Instruments Inc.
Helipot Division
Fullerton, California

73293 Hughes Products Div. of
Hughes Aircraft Company
Newport Beach, California

73445 Amperex Electronic Co.
Div. of North American
Philips Co., Inc.
Hicksville, New York

73559 Carling Electric Inc.
Hartford, Connecticut

73586 Circle F Mfg. Co.
Trenton, New Jersey

73899 JFD Electronics Corp.
Brooklyn, New York

73949 Guardian Electric Mfg. Co.
Chicago, Illinois

74199 Quam Nichols Co.
Chicago, Illinois

74217 Radio Switch Corp
Marlboro, New Jersey

74276 Signalite, Inc.
Neptune, New Jersey

74306 Piezo Crystal Company
Carlisle, Pennsylvania

74542 Hoyt Elect. Instr. Works
Penacook, New Hampshire

74970 Johnson, E. F., Company
Waseca, Minnesota

75042 International Resistance Co.
Philadelphia, Pennsylvania

75915 Littelfuse Inc.
Des Plaines, Illinois

76854 Oak Mfg. Company
Crystal Lake, Illinois

77342 American Machine
and Foundry Company
Potter & Brumfield Div.
Princeton, Indiana

77969 Rubbercraft Corp. of
California Ltd.
Torrance, California

78277 Sigma Instruments, Inc.
South Braintree, Mass.

79136 Waldes Kohinoor Inc.
Long Island City, New York

79497 Western Rubber Company
Goshen, Indiana

80031 Mepco Division of
Sessions Clock Co.
Morristown, New Jersey

80294 Bourns Laboratories, Inc.
Riverside, California

80583 Hammarlund Company, Inc.
New York, New York

80640 Stevens, Arnold Co., Inc.
Boston, Massachusetts

81073 Grayhill Company
La Grange, Illinois

81439 Therm-O-Disc. Inc.
Mansfield, Ohio

81483 International Rectifier Corp.
El Segundo, California

81590 Korry Mfg. Company
Seattle, Washington

82376 Astrom Division
Renwell Industries Inc.
East Newark, New Jersey

82389 Switchcraft Inc.
Chicago, Illinois

82415 Price Electric, Corp.
Frederick, Maryland

82872 Roanwell Corp.
Brooklyn, New York

82877 Rotron Mfg. Co., Inc.
Woodstock, New York

82879 Royal Electric Corp.
Pawtucket, Rhode Island

83003 Varo Mfg. Co., Inc.
Garland, Texas

83298 Bendix Corp.
Red Bank Division
Red Bank, Eatontown,
New Jersey

83330 Smith, Herman H., Inc.
Brooklyn, New York

83478 Rubbercraft Corp. of
America
New Haven, Connecticut

84171 Arco Electronics, Inc.
Great Neck, New York

84411 Good All Electric Mfg. Co.
(TRW)
Ogallala, Nebraska

86689 R. M. B. Corp.
Los Angeles, California

88419 Cornell-Dubilier Elec. Corp.
Electro-Mechanical Division
Fuquay Springs,
North Carolina

88690 Essex Wire Corp.
R. B. M. Division
Detroit, Michigan

89536 Fluke, John, Mfg. Co., Inc.
Seattle, Washington

89730 General Electric Company
Newark Lamp Works of
Lamp Division of Consumer
Products Group
GECO
Newark, New Jersey

90205 Best Stamp and Mfg. Co.
Kansas City, Missouri

90211 Square D. Company
Chicago, Illinois

90303 Mallory Battery Company
North Tarrytown, New York

91293 Johanson Mfg. Company
Boonton, New Jersey

91662 Elco Corp.
Willow Grove, Penn.

91737 Gremar Mfg. Co., Inc.
Wakefield, Massachusetts

91802 Industrial Devices, Inc.
Edgewater, New Jersey

91929 Minneapolis Honeywell
Regulator Company
Micro Switch Division
Freeport, Illinois

91934 Miller Electric Co., Inc.
Pawtucket, Rhode Island

93332 Sylvania Electric Products Inc.
Semiconductor Products Div.
Woburn, Massachusetts

94145 Raythion Company
Semiconductor Division
California Street Plant
Newton, Massachusetts

95146 Alco Electronics Mfg. Co.
Lawrence, Massachusetts

95264 Lerco Electronics Inc.
Burbank, California

95303 Radio Corp. of America
Comm. Receiving Tube &
Semiconductor Division
Cincinnati, Ohio

95354 Methode Mfg. Co.
Chicago, Illinois

95712 Dage Electric Co., Inc.
Franklin, Indiana

96733 San Fernando Electric Mfg. Co.
San Fernando, California

96881 Thomson Industries, Inc.
New Hyde Park
Long Island, New York

97540 Master Mobile Mount, Inc.
Los Angeles, California

97945 S. S. White Dental Mfg. Co.
Plastics Division
New York, New York

97966 CBS Electronics Div. of
Columbia Broadcasting
Systems Inc.
Danvers, Massachusetts

98094 Penta Laboratories, Inc.
Santa Barbara, California

98291 Sealectro Corp.
Conhex Div.
Mamaroneck, New York

98388 Accurate Sales Company
Culver City, California

98743 James Vibrapower Corp.
Chicago, Illinois

98925 Clevite Corp.
Semiconductor Division
Waltham, Massachusetts

99120 Plastic Capacitors, Inc.
Chicago, Illinois

99217 Southern Electronics Corp.
Burbank, California

99515 Marshall Industries
Electron Prod. Div.
Pasadena, California

Revised January 1967
Using H4-2 Dated March 1963

APPENDIX B

THE THEORY OF OPERATION OF IC CIRCUIT COMPONENTS

INTRODUCTION

In the Model 207, many circuit functions are achieved through the use of Integrated Circuit components (IC's). Because the development of these devices paralleled the technology of computers, (in many cases they were developed specifically for computer applications) the terminology is that of the computer engineer. To those engineers and technicians unfamiliar with computers, the devices may at first seem unduly complicated. Yet, each component has an exact discrete-component equivalent and can be explained in the terminology of conventional circuits.

Computer technology is based upon Boolean algebra. That is, the field of mathematics dealing with only two numbers: one and two. In the corresponding electronic technology, circuits are considered to have only two states: high or low, on or off. These two circuit conditions are termed logic 1 and logic 0. Depending upon the particular circuit elements, logic 1 can represent a high state or a low state. And conversely, logic 0 can represent a high or low state. Generally, one or the other relationship is maintained throughout a given system. In the Model 207, logic 0 represents the high state and logic 1, the low. This situation is sometimes called "negative logic."

Two types of Integrated Circuits are in common use: Diode Transistor Logic (DTL) and Resistor Transistor Logic (RTL). As the names imply, DTL elements employ diodes and transistors and RTL elements employ resistors and transistors. The components in the Model 207 are RTL Integrated Circuits.

THE RTL BUFFER

The RTL Buffer is a low-impedance, inverting, current amplifier. Because of its very low source impedance, the component can supply substantially more output current than the 2-Input Gate, the 3-Input Gate or the Flip-Flop.

The RTL Buffer logic symbol and schematic diagram are illustrated in Figure 1. Notice the circle at the apex of the symbolic triangle. It indicates that the output voltage is low when the device is activated by a high input voltage. This is true for all logic symbols used in this manual. Referring to the schematic diagram, a positive-going voltage at the base of Q1, and npn transistor, will tend to turn on the transistor, causing its collector voltage to fall. This negative going-voltage is coupled to the output terminal through emitter-follower Q2. Simultaneously, the positive-going input voltage turns on transistor Q3, diverting current from the output load. Resistor R at the input provides for the application of an external biasing voltage. Typically, an input current of 1 ma can result in a maximum output current of 16 ma.

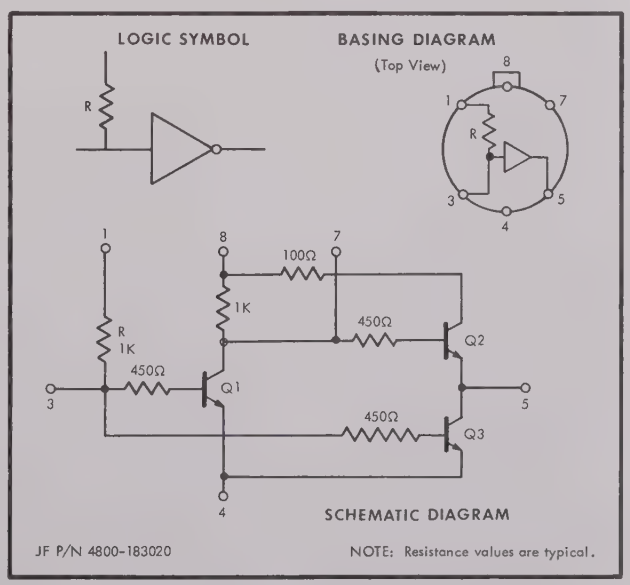


Figure 1. THE RTL BUFFER

THE RTL 2-INPUT GATE

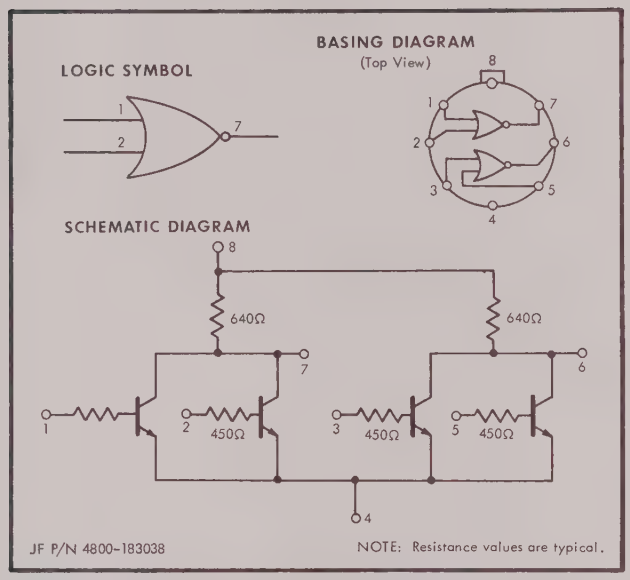


Figure 2. THE RTL DUAL 2-INPUT GATE

The 2-Input Gate is simply two npn transistors connected in parallel to a common collector load. When either transistor is turned on, the output voltage falls to its low state. In digital logic terminology, this is called a "nand" function. That is, a logic 0 at either input will result in a logic 1 at the output. The IC components used in the Model 207 contain two such gates and are called RTL Dual 2-Input Gates.

THE RTL 3-INPUT GATE

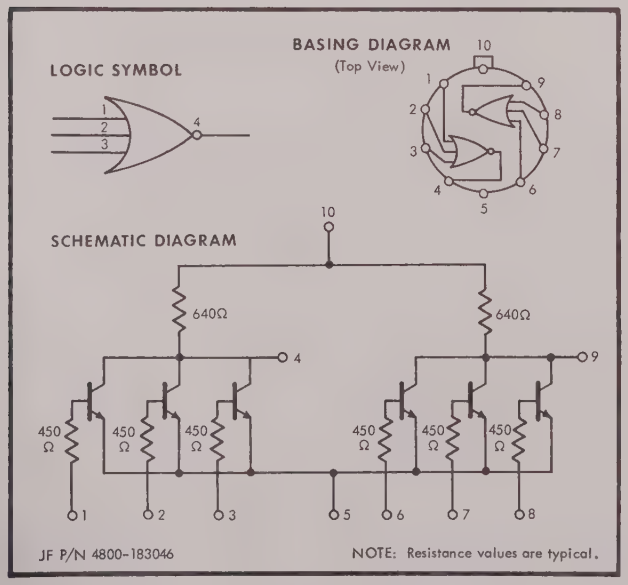


Figure 3. THE RTL DUAL 3-INPUT GATE

In the RTL 3-Input Gate, three transistors are connected to a common collector load. As in the 2-Input Gate, turning on any one of the transistors drops the output voltage to its low state. This, too, is called a "nand" function. And in digital logic terminology: a logic 0 at any input will result in a logic 1 at the output.

THE RTL FLIP-FLOP

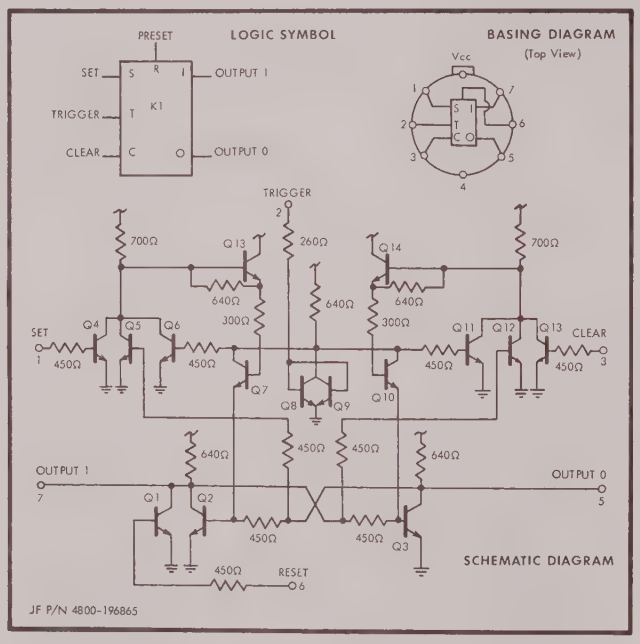


Figure 4. THE RTL FLIP-FLOP

There are fourteen transistors and 16 resistors in the RTL Flip-Flop. They are shown diagramatically in the schematic of Figure 4. Transistors Q4, Q5, and Q6, and transistors Q11, Q12 and Q13 are the principle elements of two 3-input gates. Transistors Q1, Q2 and Q3 are connected as a multivibrator. Transistors Q8 and Q9 are an inverter and transistors Q7 and Q10 are charge-storage transistors.

Transistors Q4 and Q13 serve to sense the input levels for their respective 3-input gates. Q5 and Q12 sense the output state of the multivibrator. Q6 and Q11 prevent circuit switching while the trigger input signal is low. Each of the 3-input gates control an associated charge-storage transistor (Q7 and Q10).

For the emitter-base junction of either Q7 or Q10 to charge, the transistor must be forward biased. This requires that the output of the associated gate must be high which can only occur when all three inputs are simultaneously low. The output multivibrator is cross connected to each of the gates (through Q5 and Q12) and since only one side is low at any one time, either Q7 or Q10 can charge, but not both. This is true even if both logic inputs (set and clear) are low. The base-emitter junction of Q7 or Q10 is charged during the time that the input triggering signal is high. (The high input is inverted by Q8/Q9 to a low input at the 3-input gate.)

When the trigger input signal falls, the collector of the charge-storage transistor goes high, releasing its charge. If the associated multivibrator transistor (Q2 or Q3) is off, the charge drives it on, changing the output state.

When the set input terminal is high (logic 0), charge-storage transistor Q7 is prevented from charging. However, if multivibrator transistor Q2 is conducting, charge-storage transistor Q7 will charge when the trigger input is high. Then, upon the fall of the triggering signal, Q10 triggers Q8 into conduction. In digital logic terminology, this situation is summarized as follows:

a logic 0 input at the set terminal will result in a logic 0 at output 1. Conversely, a logic 0 at the clear terminal will result in a logic 1 at output 1. Note that the set and clear input conditions are transferred to the output only upon the application of a negative-going trigger signal.

A high input (logic 0) at the present terminal will immediately set output 1 to its low state (logic 1) and output 0 to its high state (logic 0). This will occur in the absence of a triggering signal. Additionally, the high input voltage will prevent further transitions of the multivibrator until it is removed.

APPENDIX C

LF AND VLF
STANDARD FREQUENCY STATIONS

FREQUENCY & WAVELENGTH	CALL SIGN	LOCATION	CONTROLLED BY	RADIATED POWER	MAINTENANCE SCHEDULE	MODULATION AND SIGNALS
16 kHz-62.5 us	GBR	Rugby, England 55° 22' N 1° 11' W	NPL & British Post Office	40 kw	Approx. 2 hrs/ day	International Time Signals and Telegraphic Traffic.
17.8 kHz-56.1 us [1]	NAA	Cutler, Maine, U. S. A. 44° 39' N 66° 17' W	U.S. Navy	1000 kw	As required.	CW beginning odd hours UT. FSK beginning even hours UT. Phase stable. [2]
18.6 kHz-53.8 us [1]	NLK/ NPG	Jim Creek, Wash., U. S. A. 48° 12' N 121° 55' W	U.S. Navy	250 kw	1600 to 2400 UT each Thursday. [2]	CW Morse continuous. Phase stable.
20 kHz-50 us	WWVL	Fort Collins, Colorado, U. S. A. 40° 41' 51.3" N, 105° 03' 00.0" W	NBS	1/2 kw	1300 UT Tuesday to 0100 UT Wednesday every other week. [2]	CW: call sign (keyed carrier) at 00, 20, 40 min. each hour.
21.4 kHz-46.6 us [1]	NSS	Annapolis, Maryland, U.S.A. 38° 59' N 76° 27' W	U.S. Navy	85 kw	As required.	Time signals from 55 to 60th minute of each hour. CW Morse continuous. Phase stable
24 kHz-41.6 us [1]	NBA	Balboa, Canal Zone U.S.A. 09° 04' N 79° 39' W	U.S. Navy	150 kw	1200 to 1800 UT each Wednesday. [2]	Time signals on CW Morse from 55 to 60th minute of each hour except 2355 to 2400 UT. FSK teletype continuous at other times; 24.00 kHz phase stable but not 24.05 kHz. [2]

FREQUENCY & WAVELENGTH	CALL SIGN	LOCATION	CONTROLLED BY	RADIATED POWER	MAINTENANCE SCHEDULE	MODULATION AND SIGNALS
26.1 kHz- 38.3 us [1]	NPM	Lualualei, Hawaii, U. S.A. 21° 25' N 158° 09' W	U.S. Navy	300 kw	1700 to 2200 UT each Tuesday. [2]	FSK for 30 minutes beginning each odd hour followed by CW thereafter. 26.10 kHz phase stable but not 26.15 kHz.
60 kHz-16.7 us	WWVB	Fort Collins, Colorado, U. S.A. 40° 40' 28.3" N, 105° 02' 39.5" W	NBS	4 kw	1300 UT Tuesday to 0100 UT Wednesday every other week. [2]	Time information is presented in BCD by a 10 db drop in power level. Indentification is by an abrupt carrier phase advance of 45° occuring each hour beginning with the start of the 11th minute and ending with the start of the 16th minute.
60 kHz-16.7 us	MSF	Rugby, England 55° 22' N 1° 11' W	NPL & British Post Office	10 kw	Transmits 1430 to 1530 UT daily. [2]	1 Hz pulses, call sign at 10 minute intervals.

[1] Frequency subject to change. Announcements of changes are distributed by the U.S. Naval Observatory.

[2] To obtain local standard time from UT times given in above table, subtract: 5 hours in Eastern Time Zone; 6 hours in Central Time Zone; 7 hours in Mountain Time Zone; 8 hours in Pacific Time Zone.

NAVY TRANSMISSIONS: For details concerning Navy transmissions, address: Superintendent, U.S. Naval Observatory, Washington, D.C. 20390.

NBS TRANSMISSIONS: For details concerning NBS transmissions, address: Engineer in Charge, Radio Station WWVL/WWVB, Box 83E, Route 2, Fort Collins, Colorado; or Mr. David H. Andrews, Frequency-Time Broadcast Service, National Bureau of Standards, Boulder, Colorado.

MSF/GBR TRANSMISSIONS: For details concerning MSF/GBR transmissions, address: Director, National Physical Laboratory, Teddington, Middlesex, England.

WARRANTY

MONTRONICS, INC., warrants each instrument manufactured by them to be free from defects in material and workmanship. Their obligation under this Warranty is limited to servicing or adjusting an instrument returned to the factory for that purpose, and to making good at the factory any part or parts thereof; except tubes, fuses, choppers and batteries, which shall, within one year after making delivery to the original purchaser, be returned by the original purchaser with transportation charges prepaid, and which upon their examination shall disclose to their satisfaction to have been thus defective. If the fault has been caused by misuse or abnormal conditions of operation, repairs will be billed at a nominal cost. In this case, an estimate will be submitted before work is started, if requested.

If any fault develops, the following steps should be taken:

1. Notify MONTRONICS, INC., giving full details of the difficulty, and include the Model number, type number, and serial number. On receipt of this information, service data or shipping instructions will be forwarded to you.

2. On receipt of the shipping instructions, forward the instrument, prepaid, and repairs will be made at the factory. If requested, an estimate of the charges will be made before the work begins, provided the instrument is not covered by the Warranty.

SHIPPING

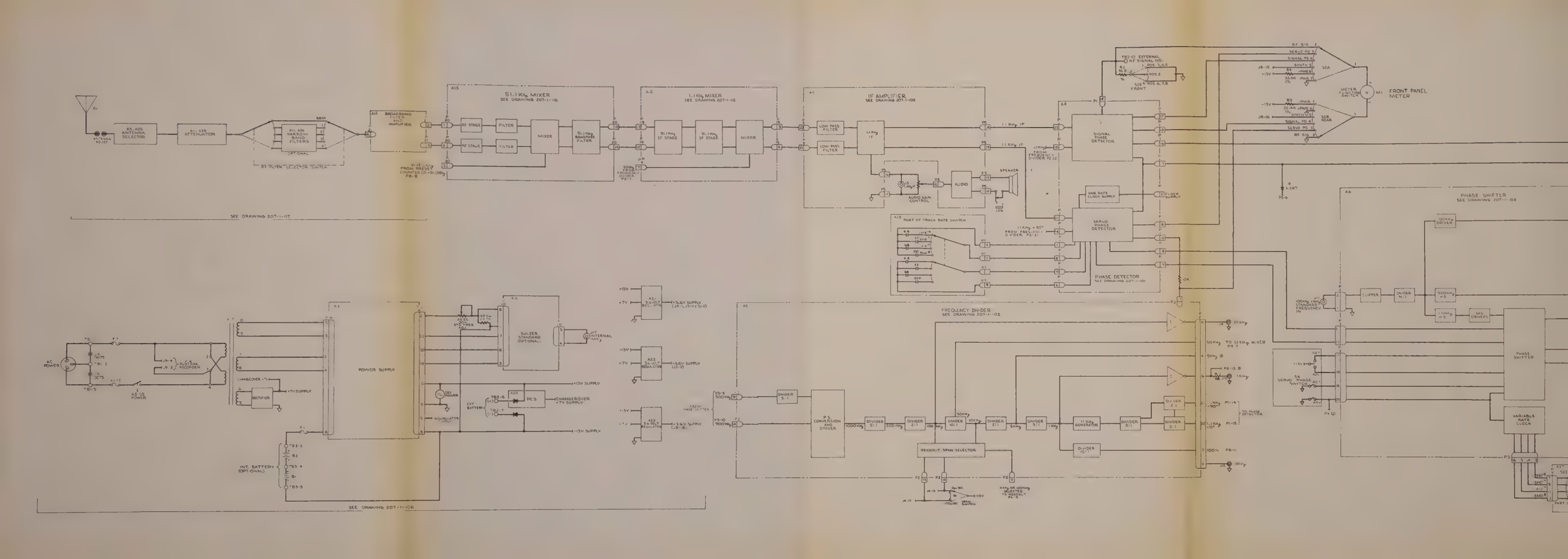
All shipments of MONTRONICS, INC., instruments should be made via airfreight prepaid. The instrument should be shipped in the original packing carton, or if it is not available, use any suitable container that is rigid. If a substitute container is used, the instrument should be wrapped in paper and surrounded with at least four inches of excelsior or similar shock-absorbing material.

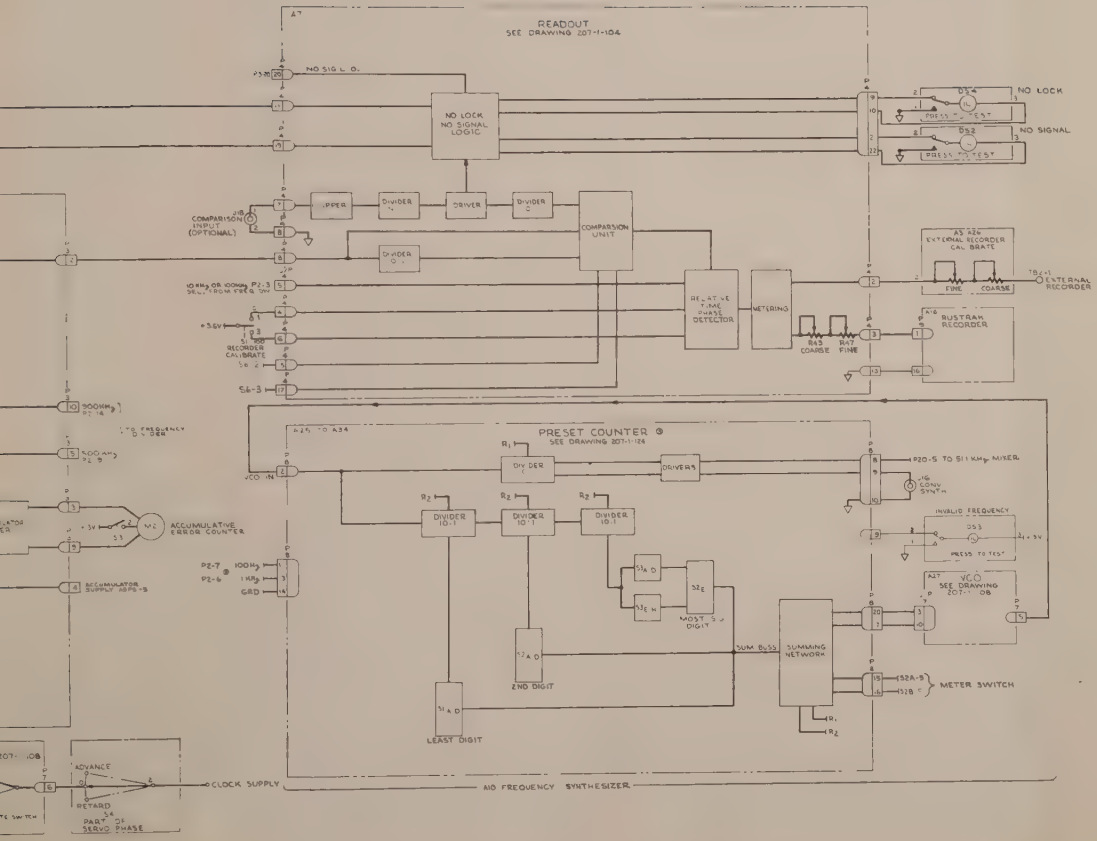
CLAIM FOR DAMAGE IN SHIPMENT

The instrument should be thoroughly inspected immediately upon receipt. All material in the container should be checked against the enclosed packing list. The manufacturer will not be responsible for shortages against the packing sheet unless notified immediately. If the instrument fails to operate properly, or is damaged in any way, a claim should be filed with the carrier. A full report of the damage should be obtained by the claim agent, and this report should be forwarded to MONTRONICS, INC. Upon receipt of this report you will be advised of the disposition of the equipment for repair or replacement. Include the model number, type number, and serial number when referring to this instrument for any reason.

MONTRONICS, INC., will be happy to answer all application questions which will enchance your use of this instrument. Please address your requests to:

MONTRONICS, INC., SUBSIDIARY OF JOHN FLUKE MFG. CO., INC., P. O. BOX 7428, SEATTLE 33, WASHINGTON, 98133. TELEPHONE (206) 776-3141


A3, A25 ANTENNA SELECTOR
A11, A36 ATTENUATOR
A11, A36 NARROW BAND FILTERS
A11 BROADBAND FILTER AND AMPLIFIER
A1.5 51.1 KHz MIXER
SEE DRAWING 207-1-116
A1.2 1.1 KHz MIXER
SEE DRAWING 207-1-115
A1.1 IF AMPLIFIER
SEE DRAWING 207-1-105
SIGNAL PHASE DETECTOR
SERVO PHASE DETECTOR
PHASE DETECTOR
SEE DRAWING 207-1-101
FREQUENCY DIVIDER
SEE DRAWING 207-1-102
PHASE SHIFTER
SEE DRAWING 207-1-103
FRONT PANEL METER
POWER SUPPLY
SEE DRAWING 207-1-117
SEE DRAWING 207-1-106



GENERAL NOTES

[illegible]

TROUBLESHOOTING TEST POINT

CIRCUIT COMMON

CHASSIS GROUND

PINS NUMBERED WITH THE SAME NUMBER ARE CONNECTED

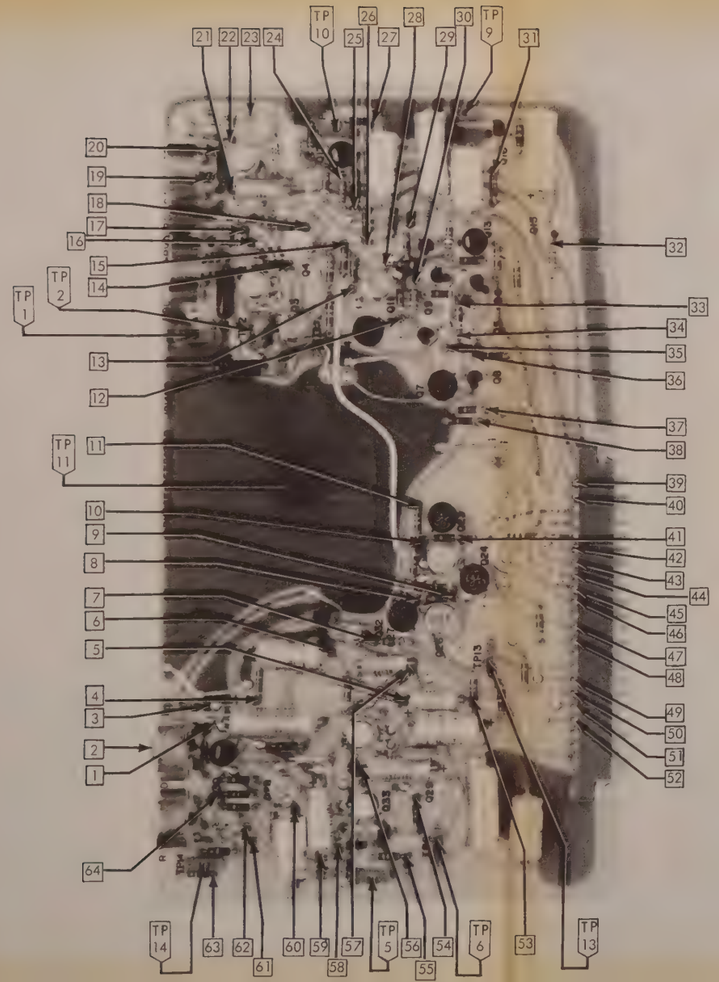
BLACK BOX UNLABELED CIRCUIT BOARD INDICATES THE BACK OF A CONNECTOR. A PREFIX E.G. (S1) SUFFIX OF A MAIN CHASSIS UNIT. (A1-S1) MEANS AT A PLUG WITH [illegible]

GENERAL INSTRUMENT CONDITIONS

ALL VOLTAGES ARE ± [illegible] DC VOLTAGES UNLESS OTHERWISE INDICATED

[illegible]

FUNCTIONAL SCHEMATIC	
DRAWING NO 207-1-100	INTERCONNECTING BLOCK DIAGRAM
VLF RECEIVER	
MODEL 207-1	
MODEL 207-1 SER NO 112 & ON	
FLUKE	MONTRONICS INC.


TP 10
TP 9
TP 2
TP 1
TP 11
TP 14
TP 5
TP 6
TP 13
21
22
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7
6
5
4
3
2
1
32
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34
35
36
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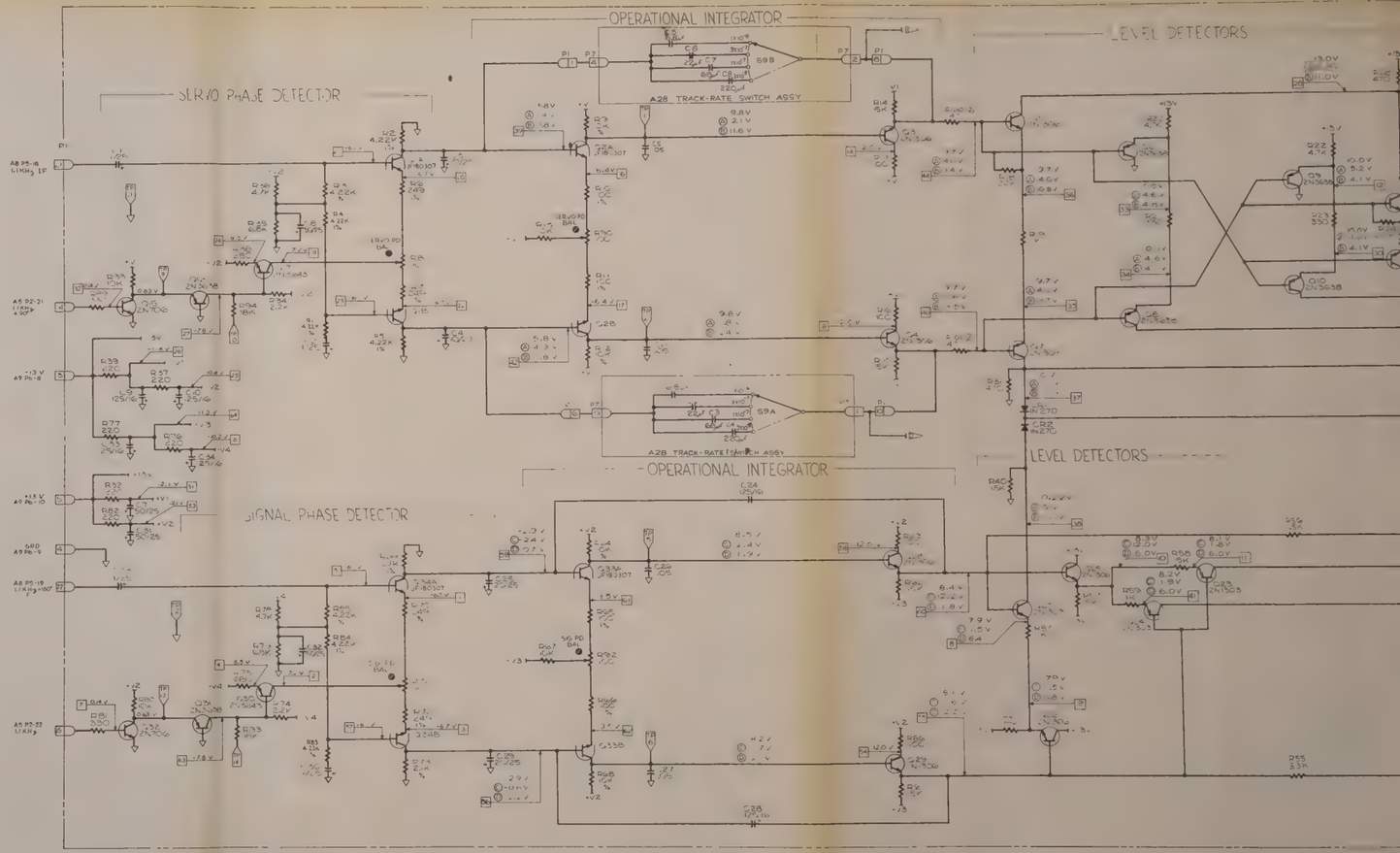
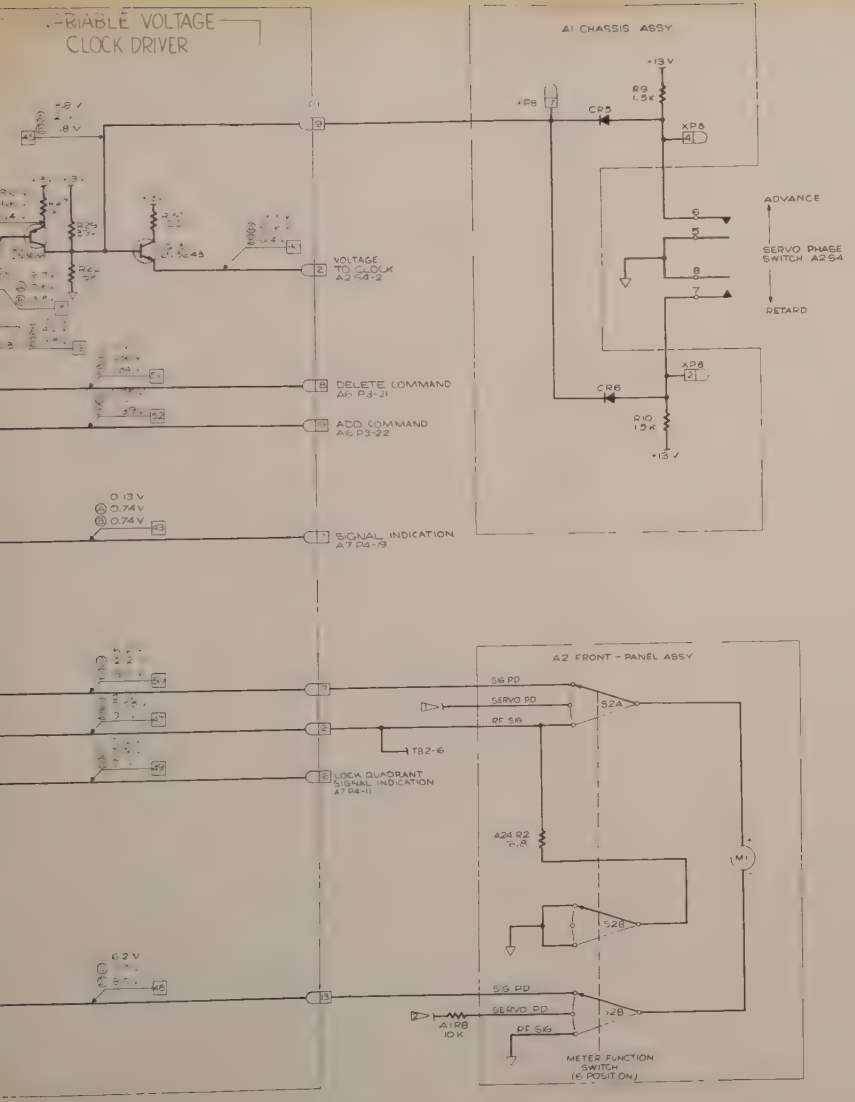

OPERATIONAL INTEGRATOR
LEVEL DETECTORS
SERVO PHASE DETECTOR
A28 TRACK-RATE SWITCH ASSY
OPERATIONAL INTEGRATOR
LEVEL DETECTORS
SIGNAL PHASE DETECTOR



MEASUREMENT CONDITIONS

FOR GENERAL CONDITIONS, SEE DWG 207-1-100.

(A) MEASURE WITH FREQUENCY STANDARD CONNECTED, FREQUENCY/KH_2 DIALS SET TO 000, AND METER NEEDLE DEFLECTING TO THE LEFT WHEN METER FUNCTION SWITCH IS SET TO SERVO PD. IF METER NEEDLE DEFLECTS TO THE RIGHT, TURN POWER SWITCH OFF AND THEN ON.

(B) MEASURE WITH FREQUENCY STANDARD CONNECTED, FREQUENCY/KH_2 DIALS SET TO 000, AND METER NEEDLE DEFLECTING TO THE RIGHT WHEN METER FUNCTION SWITCH IS SET TO SERVO PD. IF METER NEEDLE DEFLECTS TO THE LEFT, TURN POWER SWITCH OFF AND THEN ON.

(C) MEASURE WITH FREQUENCY STANDARD CONNECTED, FREQUENCY/KH_2 DIALS SET TO 000, AND METER NEEDLE DEFLECTING TO THE LEFT WHEN METER FUNCTION SWITCH IS SET TO S16 PD. IF METER NEEDLE DEFLECTS TO THE RIGHT, TURN POWER SWITCH OFF AND THEN ON.

(D) MEASURE WITH FREQUENCY STANDARD CONNECTED, FREQUENCY/KH_2 DIALS SET TO 000, AND METER NEEDLE DEFLECTING TO THE RIGHT WHEN METER FUNCTION SWITCH IS SET TO S16 PD. IF METER NEEDLE DEFLECTS TO THE LEFT, TURN POWER SWITCH OFF AND THEN ON.

NOTES:

FOR GENERAL NOTES SEE DRAWING NO 207-1-100

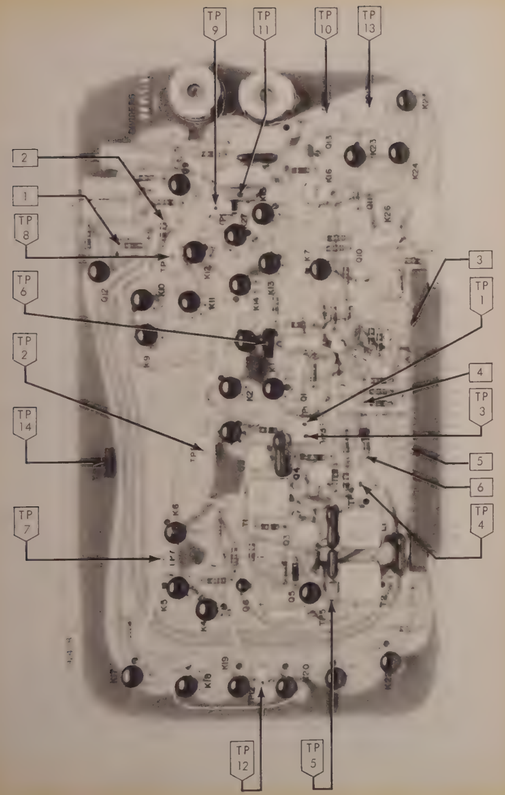
PCB CONNECTOR TERMINAL CONNECTORS REFERENCED ON THIS SCHEMATIC ARE:

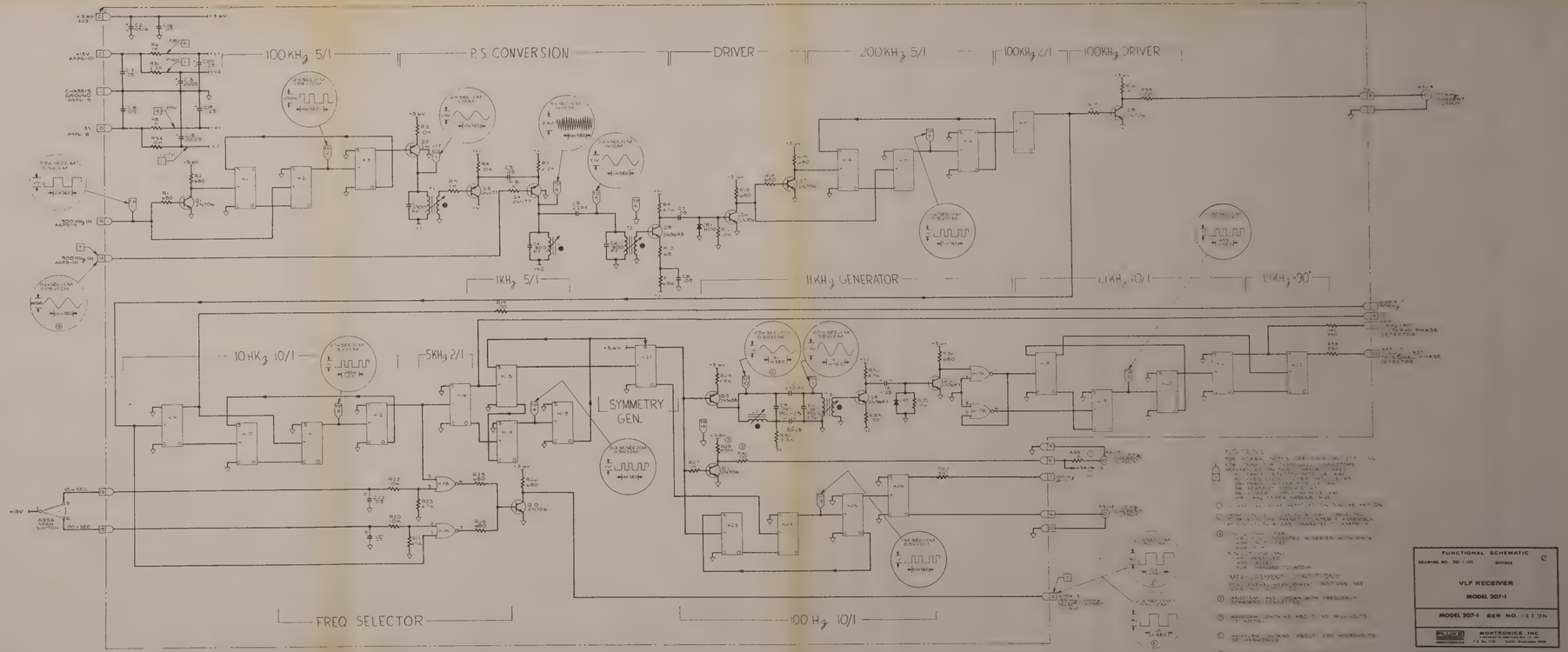
P1 - PHASE DETECTOR MODULE (A4)
P2 - FREQUENCY DIVIDER MODULE (A5)
P3 - PHASE SHIFTER MODULE (A6)
P4 - READOUT MODULE (A7)
P5 - IF AMPLIFIER MODULE (A8)
P6 - POWER SUPPLY MODULE (A9)
P7 - VOLTAGE CONTROLLED OSCILLATOR (A27)
P8 - PRESET COUNTER F ASSEMBLY (A34)

① ONLY THOSE SWITCH FUNCTIONS RELATING TO CIRCUITS ON THIS DIAGRAM ARE SHOWN

② R100 AND R101 (47), AND R102 (6.8K) NOT USED FOR S/N 112-383.

FUNCTIONAL SCHEMATIC	
DRAWING NO 207-1-101	PHASE DETECTOR
VLF RECEIVER	
MODEL 207-1	
MODEL 207-1 SER. NO. 112 & UP	
FLUKE MONTRONICS	MONTRONICS, INC. A SUBSIDIARY OF JOHN FLUKE MFG. CO., INC. P.O. Box 7428 Seattle, Washington 98133



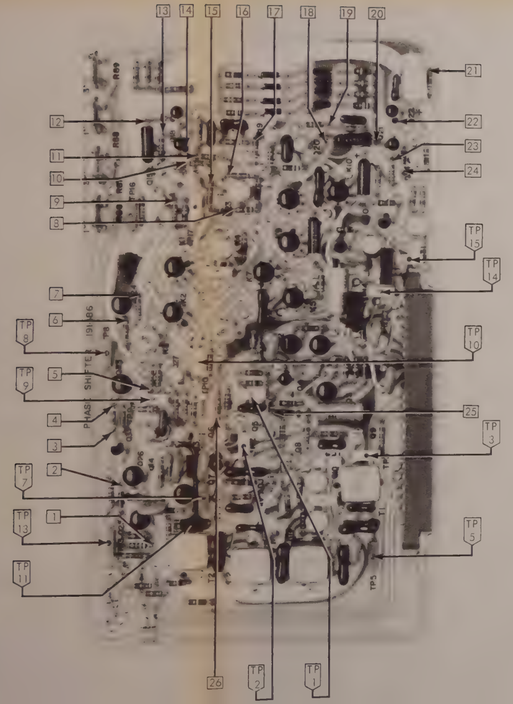


FUNCTIONAL SCHEMATIC
DRAWING NO 207-1-101 SHEET 2

VLF RECEIVER
MODEL 207-1

MODEL 207-1 SER NO. 112 & ON

FLUKE MONTRONICS INC


13
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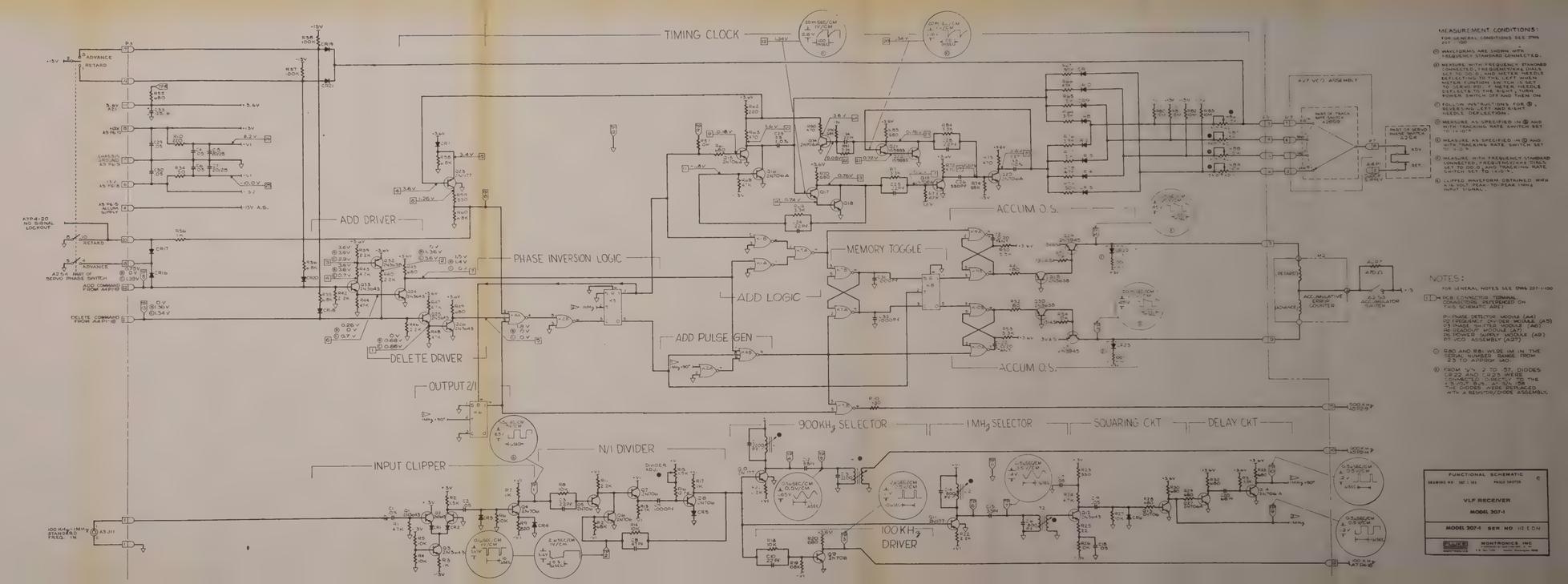
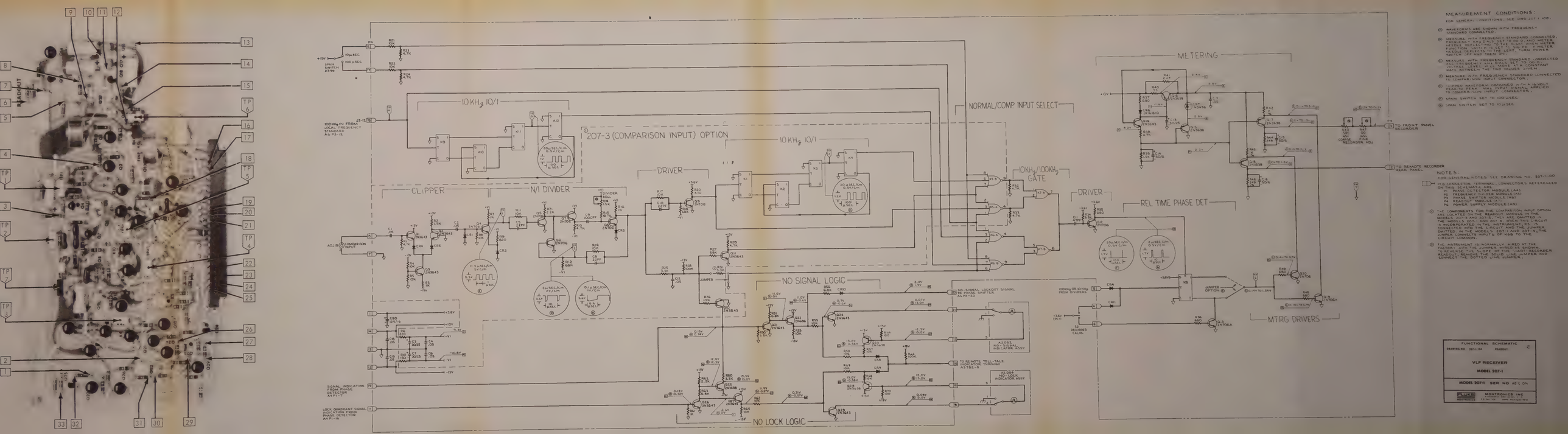
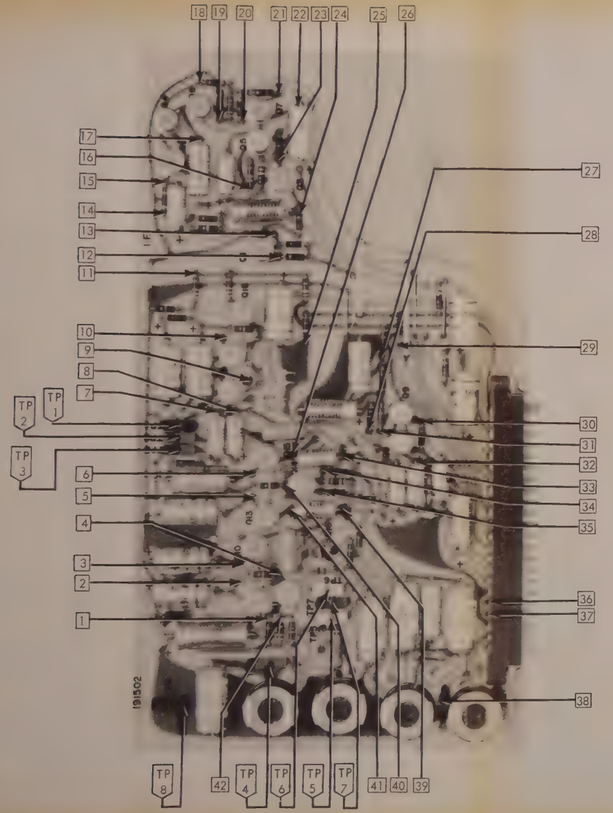
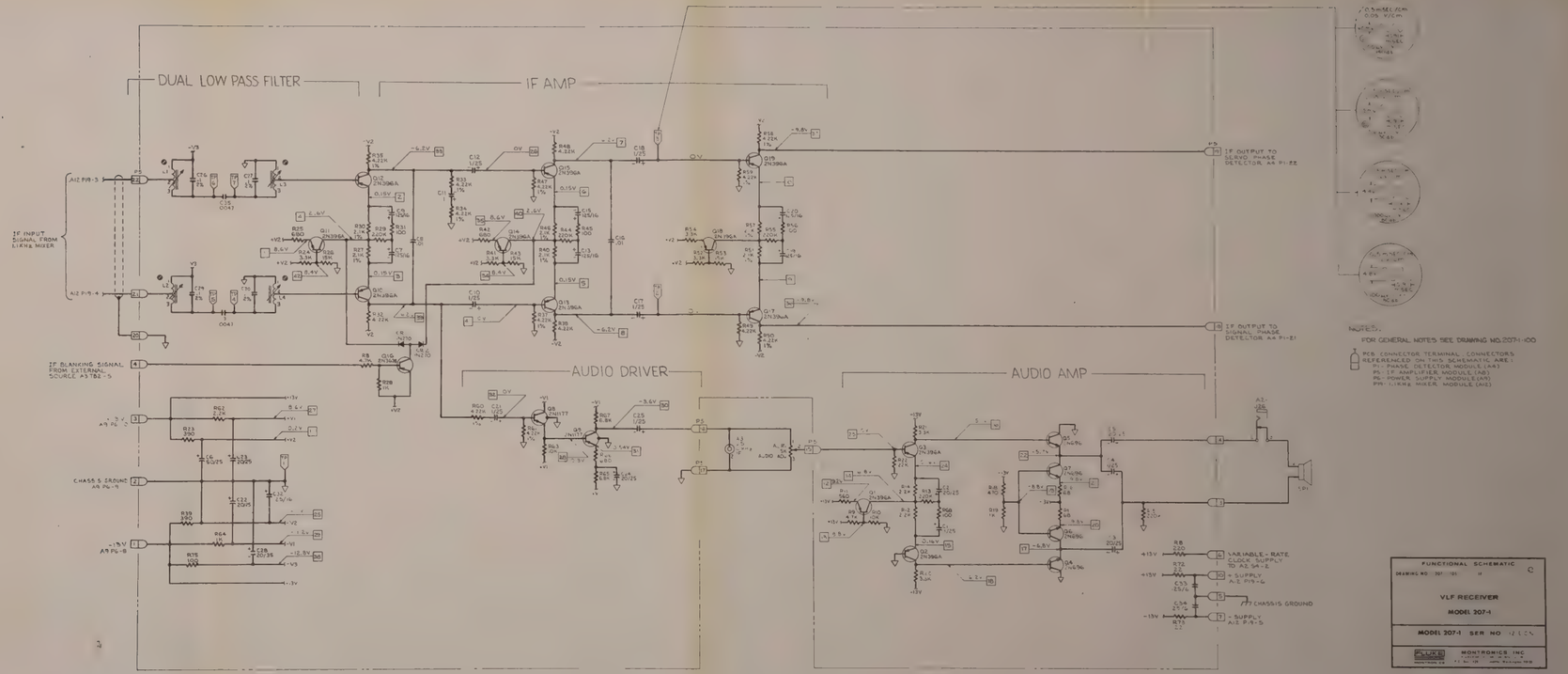
TP 15
TP 14
TP 10
TP 3
TP 5
TP 8
TP 9
TP 7
TP 13
TP 11
PHASE SHIFTER 19186
A6
A5
A4
A3
A2
A1
Z6
TP 2
TP 1


TIMING CLOCK
ADD DRIVER
PHASE INVERSION LOGIC
ADD LOGIC
ADD PULSE GEN
DELETE DRIVER
OUTPUT 2/1
INPUT CLIPPER
N/1 DIVIDER
MEMORY TOGGLE
ACCUM O.S.
ACCUM O.S.
900KH$_z$ SELECTOR
1 MH$_z$ SELECTOR
SQUARING CKT
DELAY CKT
100KH$_z$ DRIVER
A27 VCO ASSEMBLY
ADVANCE
RETARD
ACC. INDICATOR LIGHT
ACC. INDICATOR SWITCH
100 KH$_z$ 1MH$_z$ STANDARD FREQ. IN
A3 J11
MEASUREMENT CONDITIONS:
FOR GENERAL CONDITIONS SEE DWG 207-1-100
WAVEFORMS ARE SHOWN WITH FREQUENCY STANDARD CONNECTED.
MEASURE WITH FREQUENCY STANDARD CONNECTED, FREQUENCY DIALS SET TO ZERO, METER FUNCTION SWITCH SET TO ZERO ADJUST METER SO THAT NEEDLE DEFLECTS TO THE RIGHT, TURN POWER SWITCH OFF AND THEN ON
FOLLOW INSTRUCTIONS FOR ③, RELEASING LEFT AND RIGHT NEEDLE DEFLECTIONS.
MEASURE AS SPECIFIED IN ③ AND WITH TRACKING RATE SWITCH SET TO 1 X 10^{-9}
MEASURE AS SPECIFIED IN ③ AND WITH TRACKING RATE SWITCH SET TO 1 X 10^{-8}
MEASURE WITH FREQUENCY STANDARD CONNECTED, TRACKING RATE SET TO 100 X 10^{-9} AND TRACKING RATE SWITCH SET TO 1 X 10^{-8}
CLIPPED WAVEFORM OBTAINED WITH R-C PROBE TO PEAK THE INPUT SIGNAL.
NOTES:
FOR GENERAL NOTES SEE DWG 207-1-100
PCB CONNECTOR TERMINAL DESIGNATIONS REFERENCED ON THIS SCHEMATIC ARE:
P1 PHASE DETECTOR MODULE (A4)
P2 FREQUENCY DIVIDER MODULE (A5)
P3 OSCILLATOR MODULE (A6)
P4 POWER SUPPLY MODULE (A8)
P7 VCO ASSEMBLY (A27)
R80 AND R81 WERE IN IN THE EARLY NUMBER RANGE FROM 23 TO APPROX 140.
FROM S/N 2 TO 57 DIODES CR22 AND CR23 WERE CONNECTED DIRECTLY TO THE +3.7V BUS. ON S/N 58 UP THE DIODES WERE REPLACED WITH A RESISTOR/DIODE ASSEMBLY.
FUNCTIONAL SCHEMATIC
DRAWING NO 207-1-103
PHASE SHIFTER
VLF RECEIVER
MODEL 207-1
MODEL 207-1 SER. NO. 112 & ON
FLUKE
MONTRONICS, INC


MEASUREMENT CONDITIONS:
FOR GENERAL CONDITIONS, SEE DWG 207-1-100.
NOTES:
207-3 (COMPARISON INPUT) OPTION
10 KH$_z$ 10/1
DRIVER
CLIPPER
N/1 DIVIDER
NORMAL/COMP INPUT SELECT
10KH$_z$/100KH$_z$ GATE
METERING
REL TIME PHASE DET
MTRG DRIVERS
NO SIGNAL LOGIC
NO LOCK LOGIC
FUNCTIONAL SCHEMATIC
VLF RECEIVER
MODEL 207-1
MODEL 207-1 SER NO HE-ON
MONTRONICS INC




DUAL LOW PASS FILTER
IF AMP
AUDIO DRIVER
AUDIO AMP
IF INPUT SIGNAL FROM LIMG MIXER
IF BLANKING SIGNAL FROM EXTERNAL SOURCE A5TB2-5
IF OUTPUT TO SIGNAL PHASE DETECTOR A4 P1-E2
IF OUTPUT TO SIGNAL PHASE DETECTOR A4 P1-Z2
VARIABLE-RATE CLOCK SUPPLY TO A2 S4-E
+ SUPPLY A2 P19-G
CHASSIS GROUND
- SUPPLY A2 P19-S

NOTES:
FOR GENERAL NOTES SEE DRAWING NO. 207-100

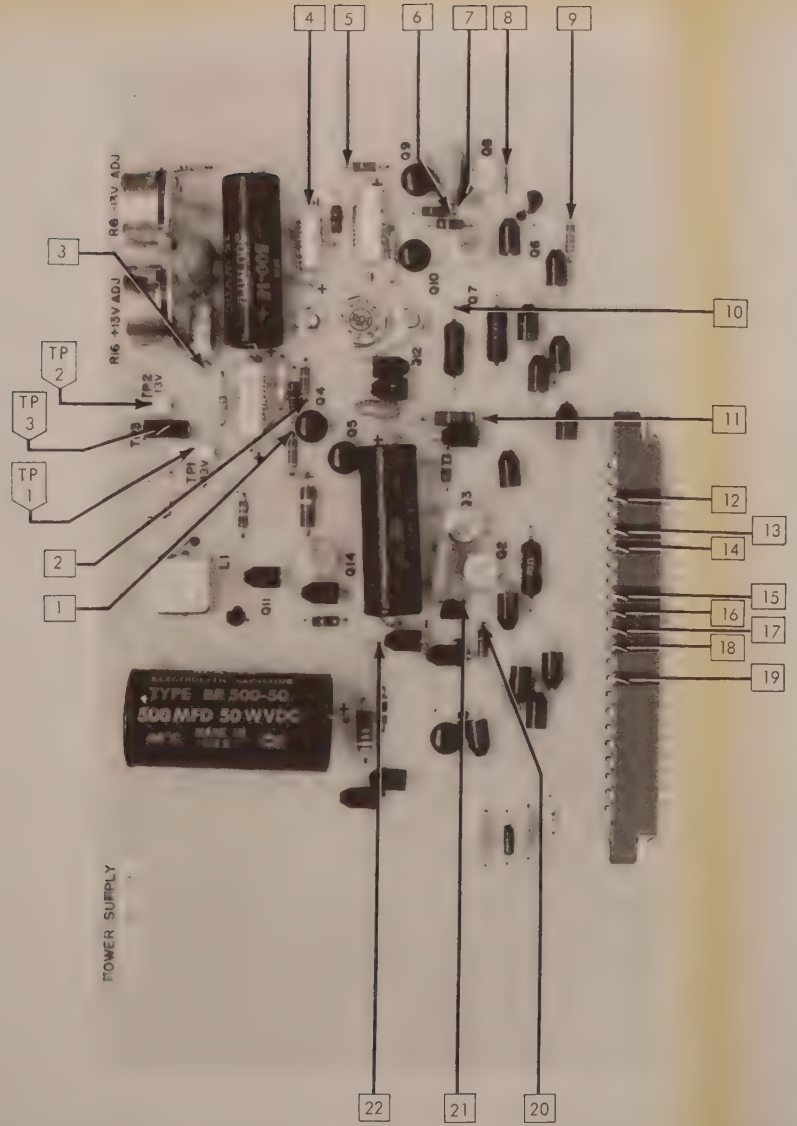
PCB CONNECTOR TERMINAL CONNECTORS REFERENCED ON THIS SCHEMATIC ARE:
P1- PHASE DETECTOR MODULE (A4)
P5- I.F. AMPLIFIER MODULE (A6)
P6- POWER SUPPLY MODULE (A9)
P19- LIMG. MIXER MODULE (A5)

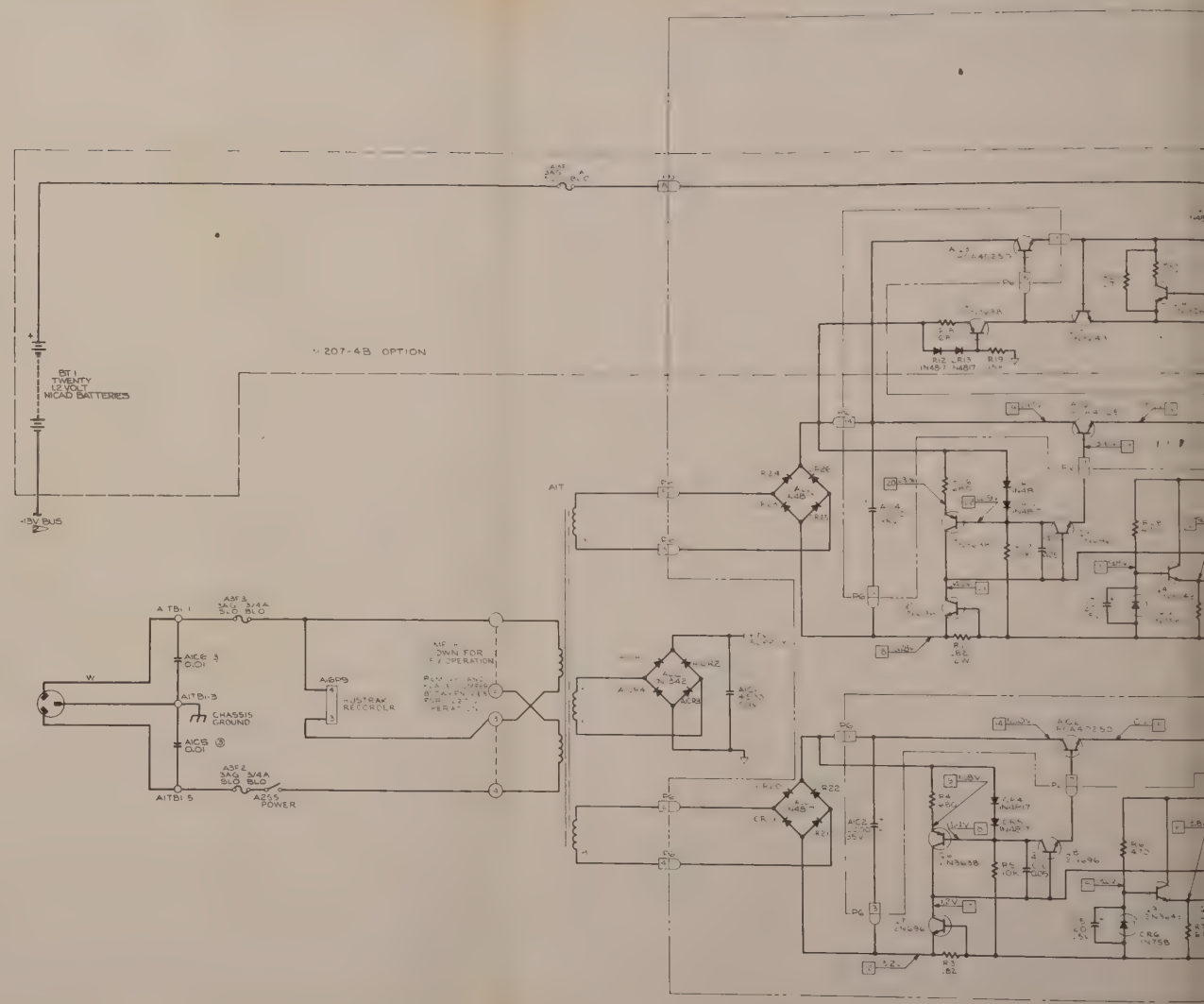
FUNCTIONAL SCHEMATIC
DRAWING NO. 207-101 M

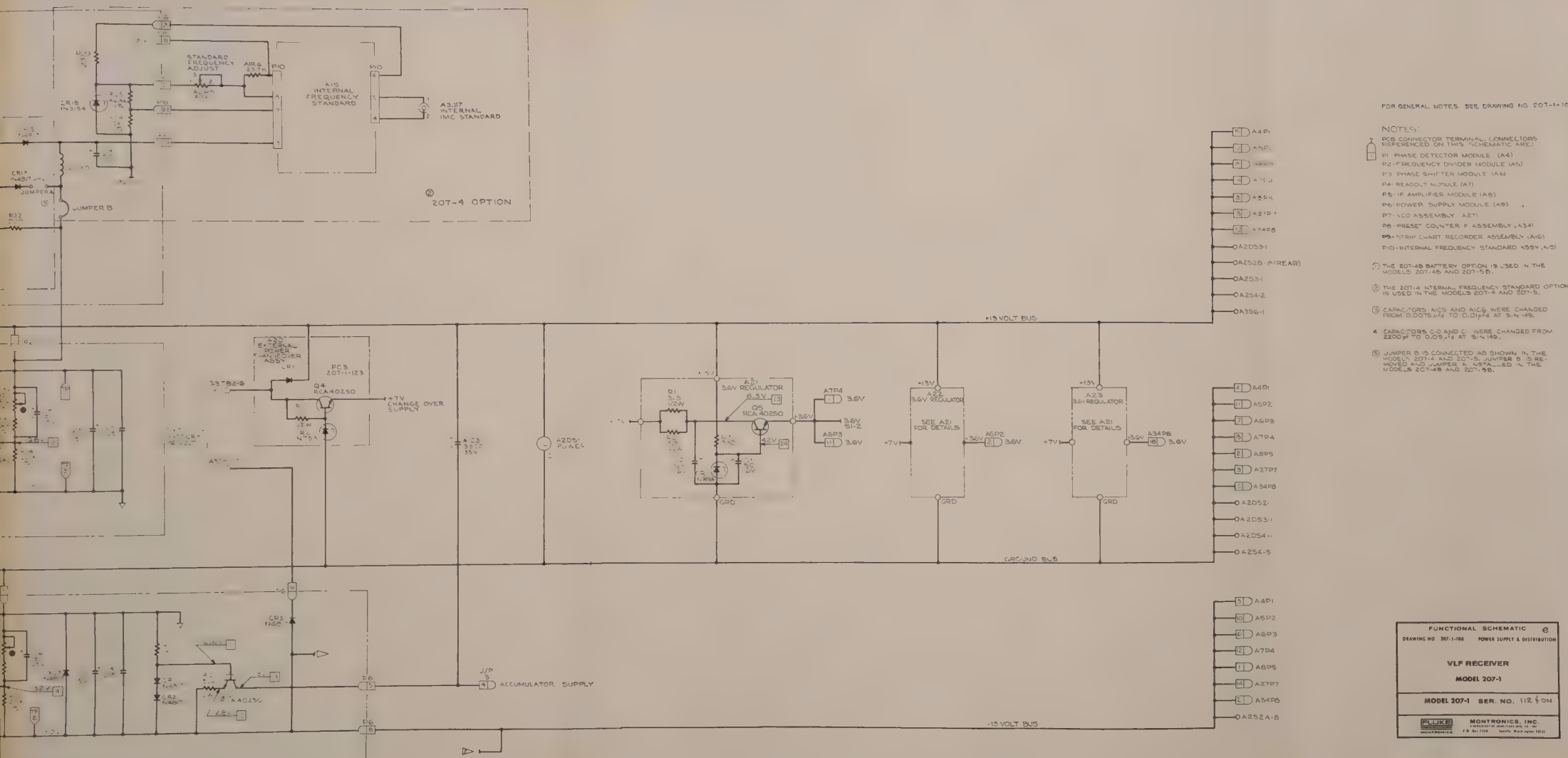
VLF RECEIVER
MODEL 207-1

MODEL 207-1 SER NO [illegible]

FLUKE | MONTRONICS, INC


4
5
6
7
8
9
3
10
TP 2
TP 3
11
TP 1
12
13
2
14
1
15
16
17
18
19
22
21
20
R6 -13V ADJ
R16 +13V ADJ
TYPE BR 500-50
500 MFD 50 W.V.DC
POWER SUPPLY


BT-1
TWENTY
12 VOLT
NICAD BATTERIES
+13V BUS
W 207-4B OPTION
A1TB1-3
CHASSIS
GROUND
ILLUSTRAX
RECORDER
POWER



FOR GENERAL NOTES SEE DRAWING NO. 207-1-101

NOTES:

PCB CONNECTOR TERMINAL (CONNECTORS REFERENCED ON THIS SCHEMATIC ARE:

P1 PHASE DETECTOR MODULE (A4)
P2 FREQUENCY DIVIDER MODULE (A5)
P3 PHASE SHIFTER MODULE (A6)
P4 READOUT MODULE (A7)
P5 IF AMPLIFIER MODULE (A8)
P6 POWER SUPPLY MODULE (A9)
P7 VCO ASSEMBLY (A27)
P8 "PRESET" COUNTER F ASSEMBLY (A34)
P9 STRIP CHART RECORDER ASSEMBLY (A16)
P10 INTERNAL FREQUENCY STANDARD ASSY (A15)

(1) THE 207-4B BATTERY OPTION IS USED IN THE MODELS 207-4B AND 207-5B.

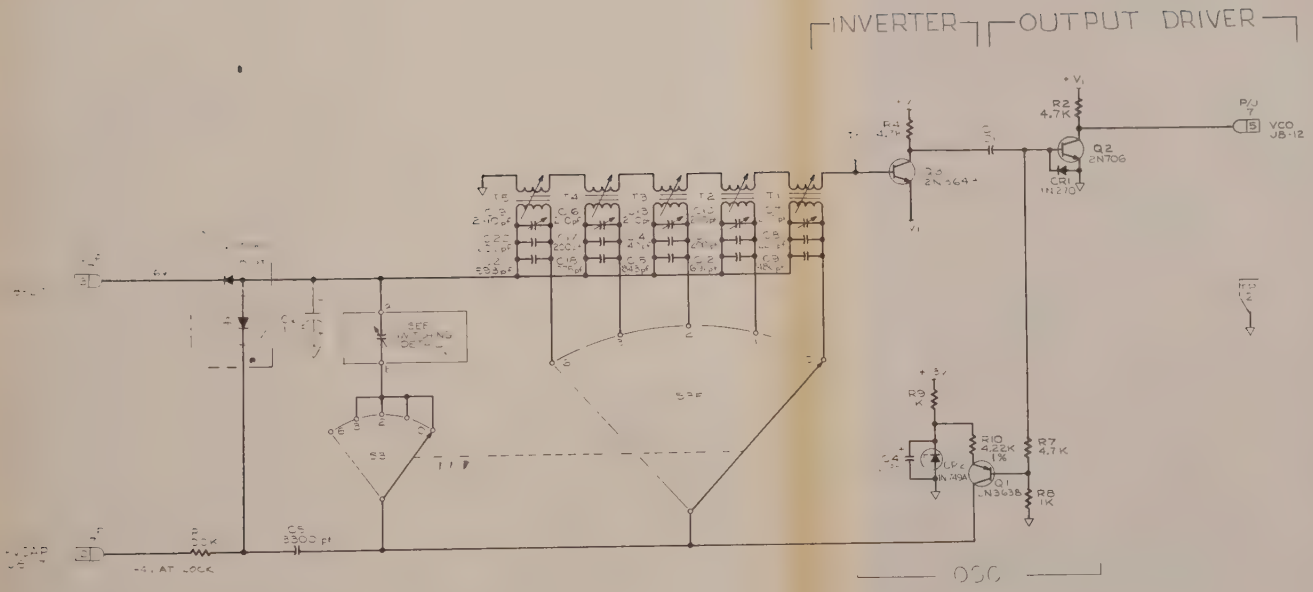
(2) THE 207-4 INTERNAL FREQUENCY STANDARD OPTION IS USED IN THE MODELS 207-4 AND 207-5.

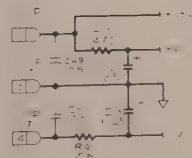
(3) CAPACITORS A1C5 AND A1C6 WERE CHANGED FROM 0.0075 μfd TO 0.01μfd AT S/N 149.

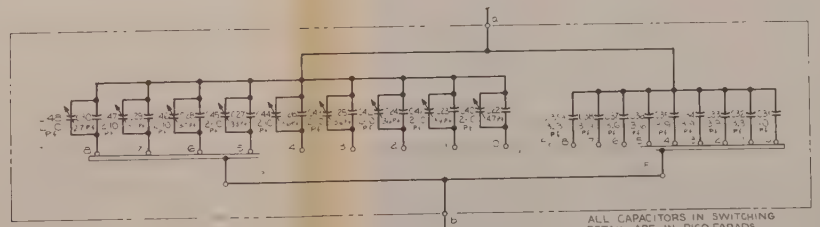
(4) CAPACITORS C10 AND C1 WERE CHANGED FROM 2200 pf TO 0.05 μfd AT S/N 149.

(5) JUMPER B IS CONNECTED AS SHOWN IN THE MODELS 207-4 AND 207-5. JUMPER B IS REMOVED AND JUMPER A INSTALLED IN THE MODELS 207-4B AND 207-5B.

FUNCTIONAL SCHEMATIC	e
DRAWING NO 207-1-106	POWER SUPPLY & DISTRIBUTION
VLF RECEIVER	
MODEL 207-1	
MODEL 207-1 SER. NO. 112 & ON	
FLUKE MONTRONICS	MONTRONICS, INC.







SWITCHING DETAIL

ALL CAPACITORS IN SWITCHING DETAIL ARE IN PICO FARADS.

S2G AND S2F SHOWN IN C POSITIONS
C31 AND C40-C46 ARE NOT CONNECTED TO b IN POSITION 1.

FUNCTIONAL SCHEMATIC

DRAWING NO. 207-1-108 VCO

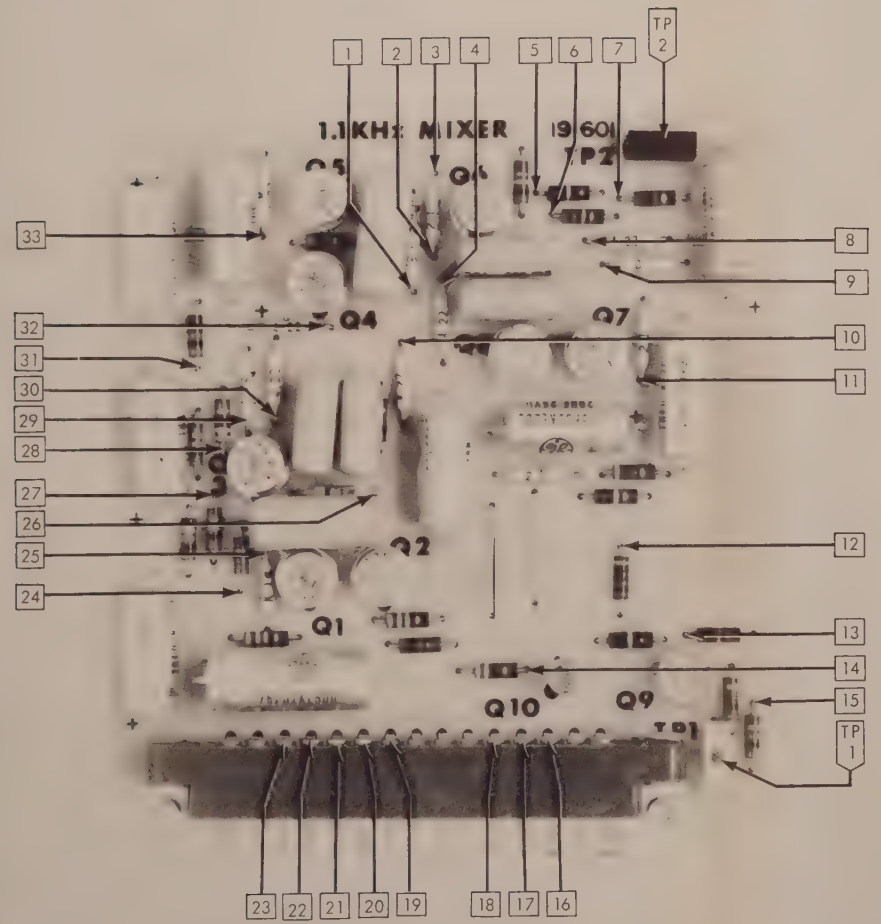
VLF RECEIVER

MODEL 207-1

MODEL 207-1 SER NO 112 & ON

FLUKE MONTRONICS

MONTRONICS, INC


1.1KHz MIXER 19601
TP2
Q5
Q6
Q4
Q7
Q2
Q1
Q10
Q9
TP1
1
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3
4
5
6
7
8
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10
11
12
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14
15
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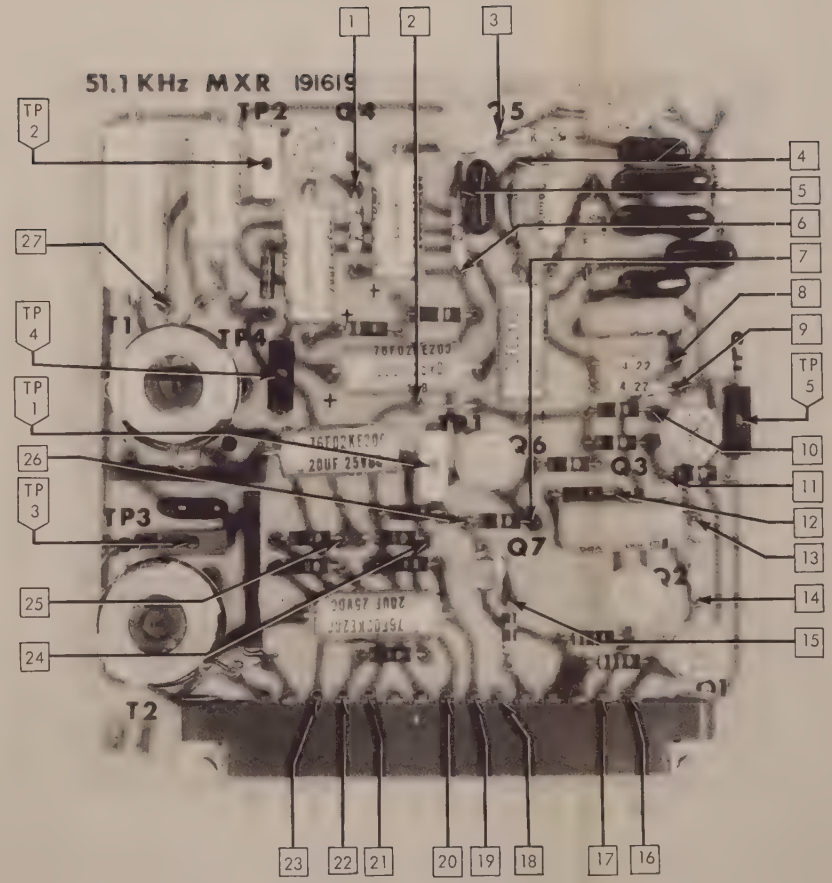
51.1 KHz MXR 191619
TP2
Q4
Q5
TP4
TP1
TP3
T1
T2
Q6
Q3
Q7
Q2
Q1
TP5
1
2
3
4
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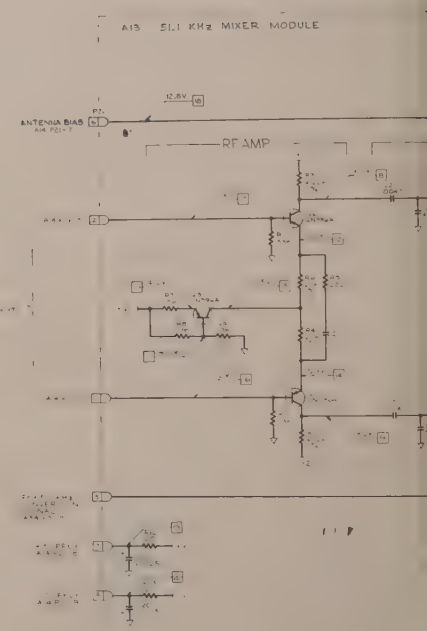
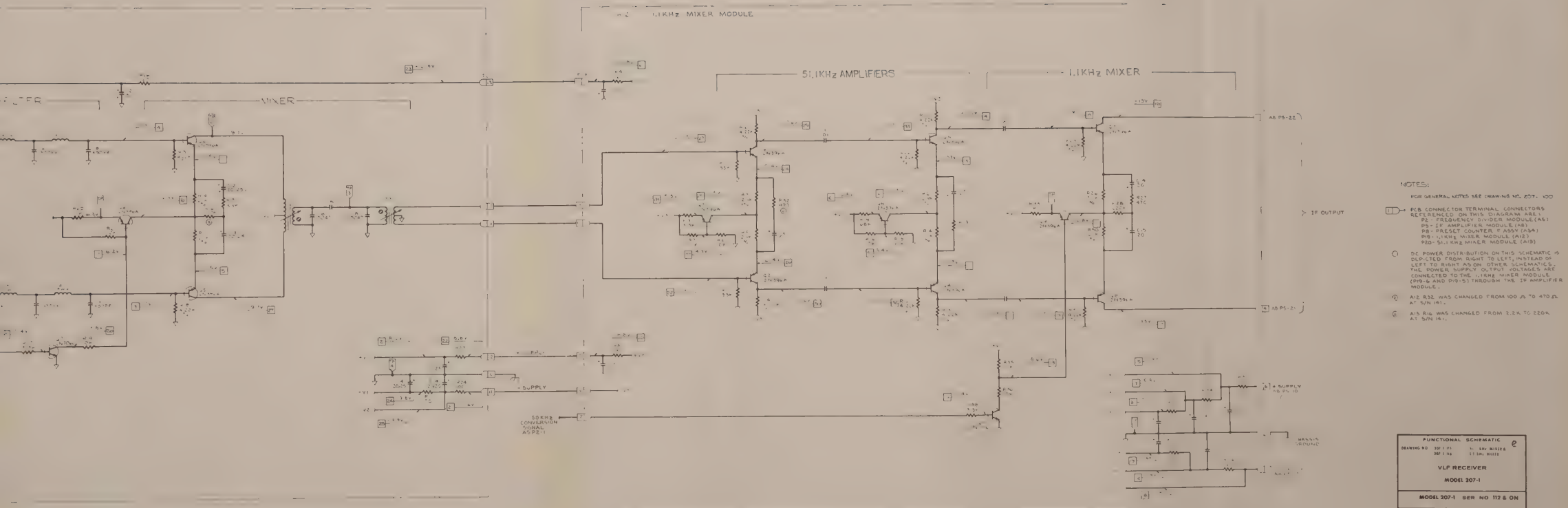
26
27


A13 51.1 KHz MIXER MODULE
12.6V
ANTENNA BIAS
RF AMP



NOTES:

FOR GENERAL NOTES SEE DRAWING NO. 207-100

□ PCB CONNECTOR TERMINAL CONNECTORS REFERENCED ON THIS DIAGRAM ARE:
P2 - FREQUENCY DIVIDER MODULE (A5)
P5 - IF AMPLIFIER MODULE (A8).
P8 - PRESET COUNTER F ASSY (A34)
P18 - 1.1KHz MIXER MODULE (A12)
P20 - 51.1 KHz MIXER MODULE (A13)

○ DC POWER DISTRIBUTION ON THIS SCHEMATIC IS DEPICTED FROM RIGHT TO LEFT, INSTEAD OF LEFT TO RIGHT AS ON OTHER SCHEMATICS. THE POWER SUPPLY OUTPUT VOLTAGES ARE CONNECTED TO THE 1.1KHz MIXER MODULE (P19-6 AND P19-5) THROUGH THE IF AMPLIFIER MODULE.

Ⓔ A12 R32 WAS CHANGED FROM 100 Ω TO 470 Ω AT S/N 141.

Ⓖ A13 R16 WAS CHANGED FROM 2.2K TO 220K AT S/N 141.

FUNCTIONAL SCHEMATIC

DRAWING NO 207-111 51.1KHz MIXER & 1.1KHz MIXER
207-116

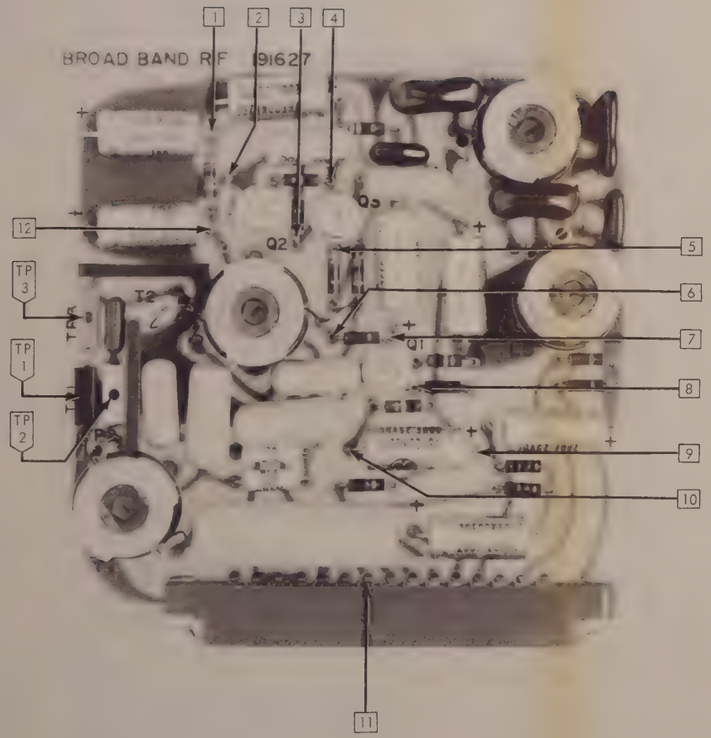
VLF RECEIVER

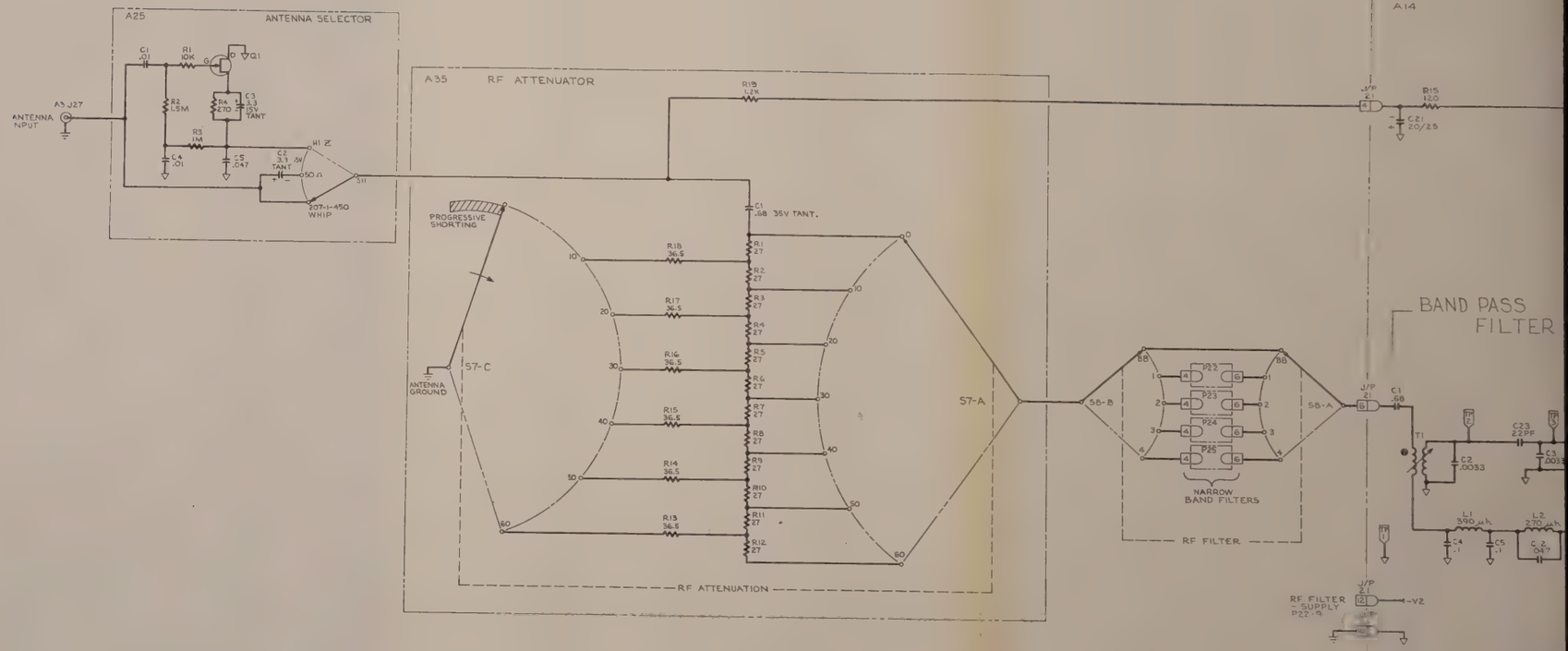
MODEL 207-1

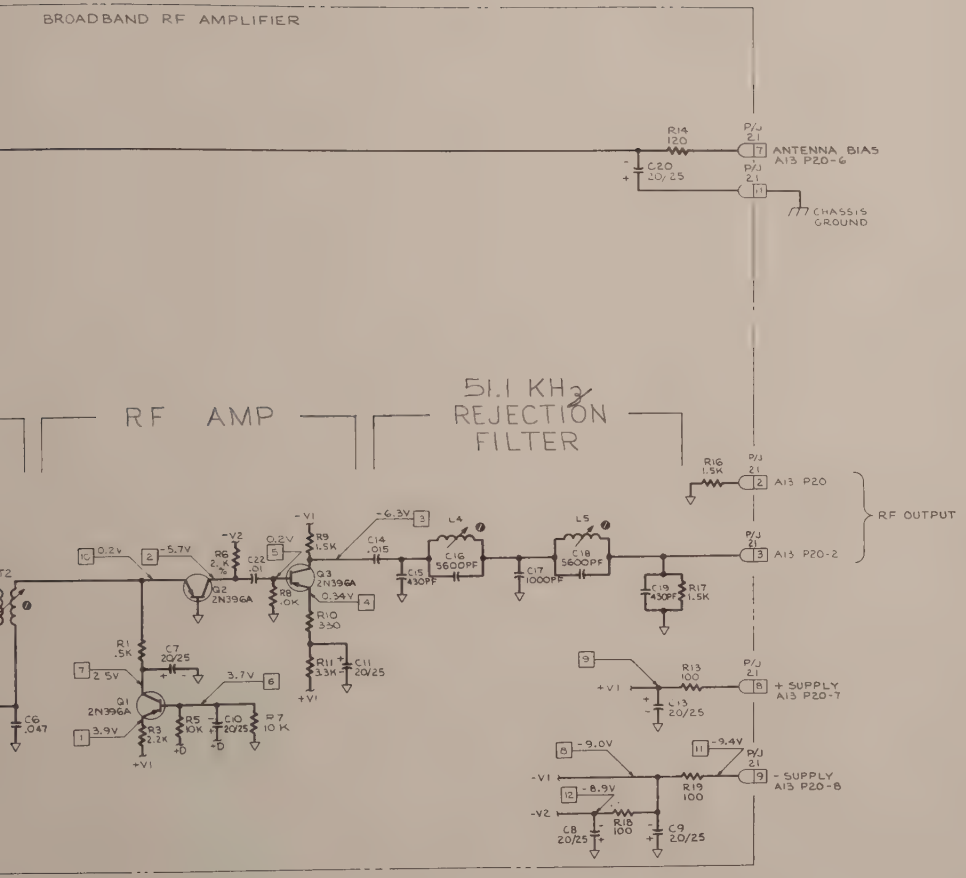
MODEL 207-1 SER NO 112 & ON

FLUKE

MONTRONICS INC


BROAD BAND RF 191627
1
2
3
4
12
TP 3
TP 1
TP 2
Q2
Q1
5
6
7
8
9
10
11


A25 ANTENNA SELECTOR
ANTENNA INPUT
A3 J27
C1 .01
R1 10K
Q1
R2 1.5M
R4 270
C3 3.3 35V TANT
R3 1M
C4 .01
C5 .047
C2 3.3 .5W TANT
50 Ω
H1 Z
S11
207-1-450 WHIP
A35 RF ATTENUATOR
R19 1.2K
C1 .68 35V TANT.
PROGRESSIVE SHORTING
ANTENNA GROUND
S7-C
S7-A
R18 36.5
R17 36.5
R16 36.5
R15 36.5
R14 36.5
R13 36.5
R1 27
R2 27
R3 27
R4 27
R5 27
R6 27
R7 27
R8 27
R9 27
R10 27
R11 27
R12 27
RF ATTENUATION
A14
J/P Z1
R15 120
C21 20/25
S8-B
S8-A
P22
P23
P24
P25
NARROW BAND FILTERS
RF FILTER
BAND PASS FILTER
C1 .68
T1
C23 22PF
C2 .0033
C3 .0033
L1 330 μh
L2 270 μh
C4 .1
C5 .1
C6 .047
RF FILTER + SUPPLY P22-9
-V2

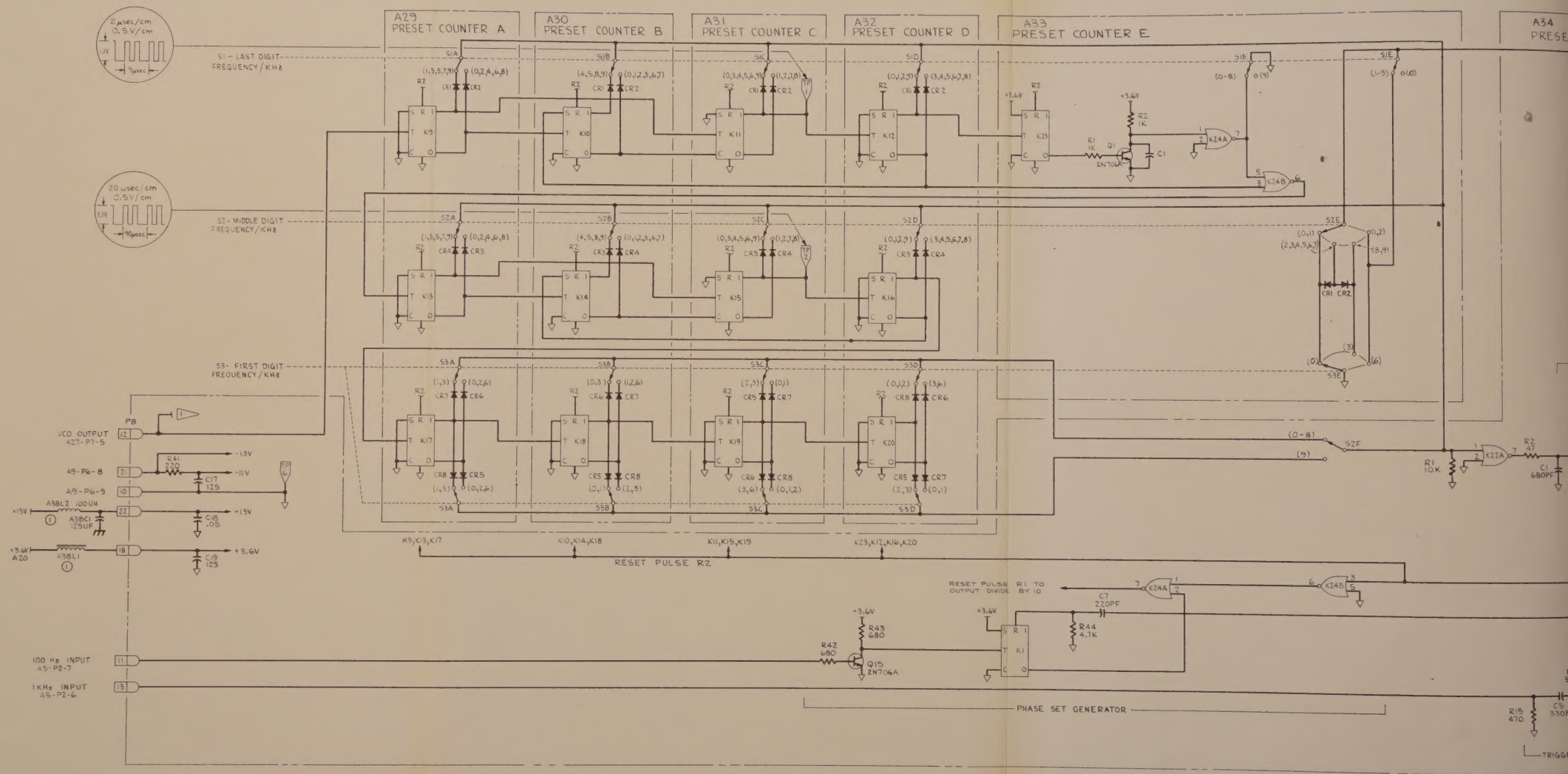


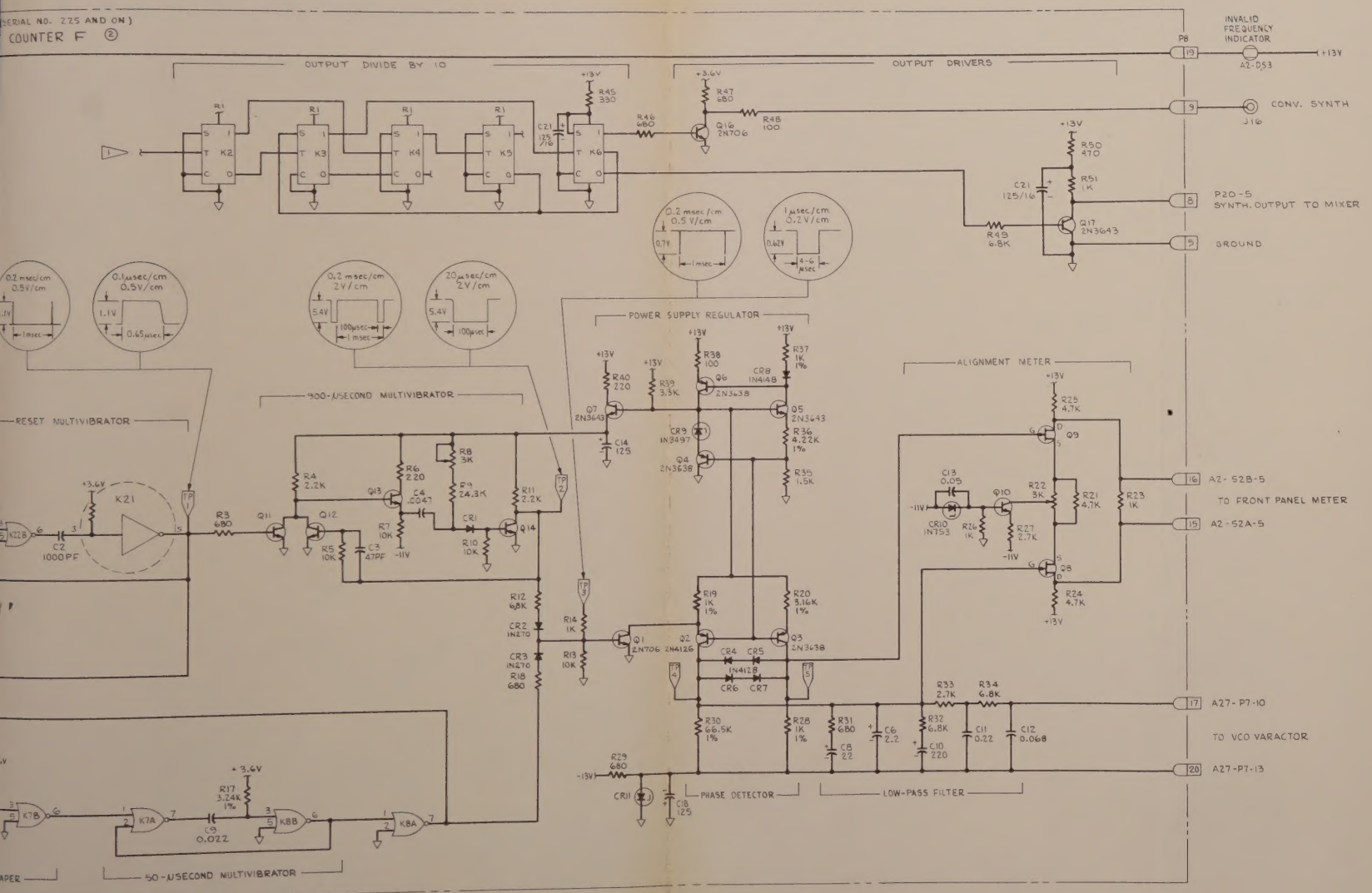
NOTES:

FOR GENERAL NOTES SEE DRAWING NO. 207-1-100

1 → PCB CONNECTOR TERMINAL-CONNECTORS REFERENCED ON THIS DIAGRAM ARE:
P20 51.1KHz MIXER MODULE (A13)
P21 BROADBAND RF AMPLIFIER MODULE (A14)
P22 RF FILTER ASSEMBLY

FUNCTIONAL SCHEMATIC	e
DRAWING NO. 207-1-117	ANTENNA INPUT AND BROADBAND RF
VLF RECEIVER	
MODEL 207-1	
MODEL 207-1 SER. NO. 112 & ON	
FLUKE MONTRONICS	MONTRONICS, INC. P.O. Box 7428 Seattle, Washington 98133


A29 PRESET COUNTER A
A30 PRESET COUNTER B
A31 PRESET COUNTER C
A32 PRESET COUNTER D
A33 PRESET COUNTER E
A34 PRESE
2 μsec/cm 0.5 V/cm
9 μsec
20 μsec/cm 0.5 V/cm
90 μsec
S1 - LAST DIGIT FREQUENCY/KHz
S2 - MIDDLE DIGIT FREQUENCY/KHz
S3 - FIRST DIGIT FREQUENCY/KHz
S1A
S1B
S1C
S1D
S1E
S1F
S2A
S2B
S2C
S2D
S2E
S2F
S3A
S3B
S3C
S3D
K9
K10
K11
K12
K13
K14
K15
K16
K17
K18
K19
K20
K23
K24A
K24B
K22A
R2
CR1
CR2
CR3
CR4
CR5
CR6
CR7
CR8
TP1
TP2
TP3
P8
VCO OUTPUT A27-P7-5
A9-P6-8
A9-P6-9
A38L2 100UH
A38C1 125UF
A38L1
R41 220
C17 125
C18 .05
C19 125
+13V
-13V
+3.6V
A20
100 Hz INPUT A5-P2-7
1KHz INPUT A5-P2-6
RESET PULSE R2
RESET PULSE R1 TO OUTPUT DIVIDE BY 10
R43 680
R42 680
Q15 2N706A
C7 220PF
R44 4.7K
R1 10K
C1 680PF
R2 47
R15 470
C9 330
PHASE SET GENERATOR
TRIGG



NOTES:

FOR GENERAL NOTES - SEE DRAWING 207-1-100.

① INDICATES THAT L1, L2 & C1 WERE ADDED TO THE CHASSIS AT SERIAL NO. 290.

② INDICATES COMPONENTS K7 THRU K6, Q16 AND Q17 ARE SHOWN ON DRAWING NO. 207-1-108, THE VOLTAGE CONTROLLED OSCILLATOR.

PRINTED CIRCUIT TERMINAL. CONNECTORS REFERENCED ON THIS SCHEMATIC ARE:
- P2 - PHASE DETECTOR MODULE (A4)
- P6 - POWER SUPPLY MODULE (A9)
- P7 - VOLTAGE CONTROLLED OSCILLATOR (A27)

MEASUREMENT CONDITIONS:

FOR GENERAL MEASUREMENT CONDITIONS - SEE DRAWING 207-1-100.

Ⓐ WAVEFORMS ARE SHOWN WITH FREQUENCY STANDARD CONNECTED.

Ⓑ MEASURE WITH FREQUENCY STANDARD CONNECTED AND FREQUENCY/KHz DIALS SET TO 60.0.

FUNCTIONAL SCHEMATIC

DRAWING NO. 207-1-104 PRESET COUNTER

VLF RECEIVER

MODEL 207-1

MODEL 207-1 SER. NO. 225 & ON

FLUKE MONTRONICS

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